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ORIGINAL ARTICLES.

I.—Eminent Living Geologists:

William Whitaker, B.A. (Lond.), F.R.S., F.G.S., Assoc. Inst. C.E., F.R. San. Inst.;

Past President of the Geological Society, the Geologists' Association, the Norwich Geological Society, the Hampshire Field Club, the Hampshire Literary and Philosophical Society, the Hertfordshire Natural History Society, the South-Eastern Union of Scientific Societies, the Croydon Microscopical and Natural History Club; of Section C, British Association, 1895; and of Section III, Congress of the Sanitary Institute (twice).

(WITH A PORTRAIT, PLATE III.)

AMONG the many distinguished geologists and men of science whom one has been accustomed to meet, year after year, at the gatherings of the Geological Society, the British Association, and the Geologists' Association during the past forty years, none has, by good *camaraderie* and hard work both in the field and study, established a better claim to our warm personal regard and esteem than Mr. Whitaker, whose portrait we present to our readers this month.

William Whitaker was born at 69, Hatton Garden, London, on the 4th May, 1836. Like the forebears of Professor Prestwich and Professor John Ruskin, Mr. Whitaker's father was an old-established wine-importer in Crutched Friars.

His early education was begun in 1846 at a boarding-school in St. John's Wood. After two years at farms in Kent he was transferred to the Grammar School of St. Albans, on the Chalk, Reading Beds, and Glacial Drifts, with which his name and work, as a geologist, were in after years to be so long and intimately connected in the East of England.

From St. Albans he entered University College, Gower Street, in 1852, where, a quarter of a century earlier, Prestwich had been a student. Here he ultimately devoted himself to science, beginning with chemistry and then studying geology under Professor Morris, through whose teaching he gained much valuable geological knowledge, to be applied in later years in the field. He took his B.A. degree in the University of London, with honours in chemistry, in 1855.

It was in his early student days that he became acquainted with Professor T. Rupert Jones, F.R.S., at that time Assistant Secretary to the Geological Society and editor of its Quarterly Journal, working for some months as Professor Rupert Jones' volunteer assistant, and afterwards for a time he was engaged as assistant in the Museum of the Society. Here he developed his interest in geology and bibliographical research, which governed his career in after life.

On the 1st of April, 1857, Whitaker joined the English staff of the Geological Survey of the United Kingdom, under Sir R. I. Murchison, with Ramsay as Local Director, and Aveline, Bristow, Howell, and Hull among the senior officers. He was at first engaged, with Professor E. Hull, T. R. Polwhele, and Hilary Bauerman, on the geology of parts of Oxfordshire and Berkshire, and on the country around Brill, in Buckinghamshire; and later on, with H. W. Bristow, on Berkshire and the northern part of Hampshire. Early in 1859 he was elected a Fellow of the Geological Society, and now is 29th Fellow in seniority. In 1863 Mr. Whitaker was promoted to the rank of Geologist.

The writer recalls with pleasure a week's holiday spent with Whitaker in Bath, during the Meeting of the British Association in 1864, when several agreeable evenings were passed with the late William Pengelly (familiarly known at that time as *Pun*-gelly), Professor Rupert Jones, Joseph Beck, and some others, when much innocent fun and enjoyment at dinner relieved the more serious business of the day's scientific proceedings. Many pleasant geological excursions were also taken to Frome, the Vallis, to Watchet and elsewhere.

Proceeding on in his work he took up the original survey of the geology of the London Basin, particularly the Chalk and Eocene beds of the Southern and Western Tracts from Newbury eastwards into Surrey, Southern Bucks, Middlesex, Herts, Essex, and Kent.

In his researches, which extended for more than thirty years, Whitaker worked over ground much of which had been rendered classical by Prestwich's earlier researches, following, more than any other man had done, in his footsteps. Speaking of this period of Prestwich's work (1841–1860), Whitaker remarked "that it might well be called 'the Prestwichian period,' as it was he who first clearly made out the structure of the London Basin" (Mem. Geol. Surv., vol. iv, p. 395). The Drift Survey of the London area was in 1869 carried out mainly under his guidance, though nominally under the superintendence of Mr. Bristow.

Later on we find Whitaker working out the geology of Walton-on-the-Naze and Harwich and other parts of the counties of Essex, Suffolk, and Cambridgeshire. Indeed, it may be said that the whole of Essex and Suffolk and parts of West Norfolk and Cambridgeshire were surveyed by him, with the aid of colleagues who worked under his direction.

Among those who, at various times, worked under his superintendence were Richard Trench, H. B. Woodward, W. H. Penning, W. H. Dalton, Thomas Adams, F. J. Bennett, W. A. E. Ussher, J. H. Blake, A. C. G. Cameron, C. E. Hawkins, S. B. J. Skertchly, Clement Reid,

and A. J. Jukes-Browne. Although for many years he thus superintended the work of others, it was not until 1882 that he was appointed District Surveyor, a post which he held until he retired from the public service on October 22nd, 1896. During the later years of his official career he was stationed at Southampton, and surveyed some portions of South Hampshire, while at the same time he was superintending the re-surveys in progress in no less than seven other counties, Bedford, Berks, Bucks, Dorset, Northants, Oxford, and Wilts.

It is on record among the anecdotage of the Survey hammerers, that upon one occasion Murchison (observing the exemplary industry and excellence of Whitaker's work in the field) said to his lieutenant, Professor (afterwards Sir) A. C. Ramsay, "Don't you think, Ramsay, that Whitaker has worked long enough in the Eastern Counties, where he gets nothing but soft squashy materials, and no good hard rocks to hammer? We might send him to the North or West, and give him some decent *solid geology* instead of this interminable Chalk, London Clay, and Drift"; to which Ramsay replied, "But, Sir Roderick, I assure you Whitaker *likes to work where he is*." "If that is really the case," said Sir Roderick, "pray let him stay there, but I am sorry for him all the same." And he stayed there and did very excellent geological work for very many more years.

Whitaker was early in the field as an ardent student of subaërial denudation, and communicated an excellent paper on "Cliffs and Escarpments of the Chalk and Tertiary Strata" to the Geological Society on May 8th, 1867; the full text of which, not being regarded apparently as suitable for the Quarterly Journal, appeared in the Geological Magazine in that year, p. 447, and Part II, p. 483. It is now regarded as a geological classic.[1]

As a corollary to Mr. Whitaker's geological labours in maps and memoirs, which by a reference to the annexed list of his published works will be seen to be very extensive, he has always had a strong passion for bibliographical research and the making of lists of references to the labours of all previous writers in whatever branch of geology upon which he, or his friends and colleagues, were specially engaged. One of his activities in this direction led him to edit a "Geological Record," which, owing in part to the arduous nature of his other work, but perhaps in larger measure owing to the shortcomings of some of those who had promised to help and failed to produce their MSS. when required, he was compelled at length to relinquish, after carrying it on for six years.

Another subject to which he has devoted much attention has been the accumulation of evidence connected with the sinking of wells, believing, like the ancients, that by seeking diligently in these places he would in time arrive at the home of Truth.

He retired from the Geological Survey in October, 1896, and has since resided at 3, Campden Road, Croydon. He has been for more than thirty years one of the leading authorities upon questions of

[1] See the very high commendation of this memoir by Charles Darwin in his work on "The formation of Vegetable Mould through the action of Earthworms," 8vo, 1883 ed., p. 234 (Murray).

water-supply for towns and public buildings, principally in the eastern and south-eastern counties of England. He has also reported on the Kent coal borings.

No man has been more assiduous in helping others individually or by taking part in the ordinary meetings, councils, and committees of various learned societies and field clubs. As a director of excursions he has ever proved a popular, a ready, and most able guide, as may be gathered from the Proceedings of the Geologists' Association in particular. Recognition of his services has been frequently shown by his election to Presidential chairs, an honour not without attendant labour, if we may judge from the record of his addresses. Other recognitions have been given in the awards by the Council of the Geological Society in 1886 of the Murchison Medal, and in 1906 of the singularly appropriate Prestwich Medal, which, as the President of the Geological Society (Dr. J. E. Marr) said, had been awarded "as an acknowledgment of the value of your researches among the Tertiary strata of the London and Hampshire Basins . . . . . which were advanced in a high degree by the founder of the medal. You have also followed in the footsteps of Prestwich in matters of economic geology—the question of water supply and the study of underground geology—for which you, the recipient of the medal, like its founder, have done so much."

Twenty years earlier, in 1886 (when awarding Mr. Whitaker the Murchison Medal), Professor Bonney said: "Your papers on the western end of the London Basin and on the Lower London Tertiaries of Kent deserve to be ranked with the classic memoirs of Prestwich as elucidating the geology of what I may call the Home District."

Mr. Whitaker claims one negative virtue, he does not smoke; and one positive virtue, he walks.

The following is a list of Mr. Whitaker's published papers:—

1. *Papers published in the* Geological Magazine.

1864. "On some Evidence of there being a Reversal of the Beds near Whitecliff Bay, Isle of Wight": vol. i, pp. 69–71.
"On the Cliffs at Folkestone"? ibid., pp. 212–215.

1867. "On Subaërial Denudation, and on Cliffs and Escarpments of the Chalk and Lower Tertiary Beds": vol. iv, pp. 447–454, 483–493. Reprinted, with small additions, 8vo, Hertford, pp. 28. See also vol. v, pp. 46–47.

1869. (With H. W. Bristow.) "On the Formation of the Chesil Bank, Dorset": vol. vi, pp. 433–438, pl. xv. See also pp. 574–575.
"On a Raised Beach at Portland Bill, Dorset": ibid., pp. 438–440.
"On the Connection of the Geological Structure and the Physical Features of the South-East of England with the Consumption Death-rate": ibid., pp. 499–505.

1871. "On the Chalk of the Cliffs from Seaford to Eastbourne, Sussex": vol. viii, pp. 198–200.

1872. "On the Occurrence of the 'Chalk Rock' near Salisbury": vol. ix, pp. 427–428. Reprinted from Mag. Wilts. Archæol. N.H. Soc., vol. xiii (1871), pp. 92–93.

1873. "Remarks on the Section at Shaw Clay Pit": vol. x, pp. 142–143. Printed in advance of Trans. Newbury District Field Club, vol. ii (1878), pp. 3–6.

1886. "On a Recent Legal Decision of Importance in Connection with Water Supply from Wells": dec. iii, vol. iii, pp. 111–114. Reprinted from Trans. San. Inst., vol. vii.
"On the Waterworks at Goldstone Bottom, Brighton": ibid., pp. 159–161. (Abstract, on p. 32, alone referred to in Index.)

1890. "Coal in the South-East of England": dec. III, vol. vii, pp. 13–14.
"Suggestions on Sites for Coal-search in the South-East of England": ibid., pp. 514–515. Reprinted, with a little difference, from Brighton and County Mag., pp. 170–172.
1904. "On a Great Depth of Drift in the Valley of the Stour": dec. V, vol. i, p. 511; and Rep. Brit. Assoc. for 1904, pp. 343–344 (1905).

2. *Geological Survey Publications.*

(*a*) List of Sheets of the Map of the Geological Survey prepared by or partly by Mr. Whitaker: 1 (N.W., S.W., S.E.), 3, 6, 7, 8, 12, 13, 14, 45 (S.E.), 46 (N.W., N.E., S.W., S.E.), 47, 48 (N.W., N.E., S.E.), 49 (N., S.), 50 (N.E., S.W.), 65, 69; besides superintending the survey of several others. And of the New Series, Sheets 299, 315, 316; besides superintending the re-survey of others.
(*b*) Sheets of the Horizontal Sections: 56, 73, 74, 79, 84, 120, 125.
(*c*) Memoirs.
1861. (With E. Hull.) "The Geology of Parts of Oxfordshire and Berkshire."
1862. (With H. W. Bristow.) "The Geology of Parts of Berkshire and Hampshire" (small part).
1864. "The Geology of Parts of Middlesex, Hertfordshire, Buckinghamshire, Berkshire, and Surrey."
(With A. H. Green.) "The Geology of the Country round Banbury, Woodstock, Bicester, and Buckingham" (small part).
1872. "The Geology of the London Basin . . . The Chalk and the Eocene Beds of the Southern and Western Tracts."
1875. "List of Books, Papers, etc., in the Geology of Rutland, etc.": pp. 294–301.
"Guide to the Geology of London and the Neighbourhood." 2 editions; others in 1880, 1884, 1889, 1901.
1876. (With H. B. Woodward.) "Chronological List of Books, Papers, etc., on the Geology, Mineralogy, Palæontology, etc., of Gloucestershire and Somersetshire": pp. 216–255 of "Geology of East Somerset and the Bristol Coalfields."
1877. "The Geology of the Eastern End of Essex" (Walton Naze and Harwich).
1878. (With W. H. Penning and others.) "The Geology of the North-West Part . . . of Essex and the North-East Part of Herts . . ."
1880. "The Geology of the Neighbourhood of Colchester" (small part).
1881. "List of Works on the Geology of Cambridgeshire": pp. 170– . . of "The Geology of the Neighbourhood of Cambridge."
(With F. J. Bennett and J. H. Blake.) "The Geology of the Neighbourhood of Stowmarket."
(With H. B. Woodward.) "List of Papers, etc., on the Geology of Norfolk": pp. 171–204 of "The Geology of the Country around Norwich."
1885. "The Geology of the Country around Ipswich, Hadleigh, and Felixstow."
"List of Works on the Geology, etc., of Denbighshire and Flintshire": pp. 59–73 of "The Geology of the Coasts adjoining Rhyl, Abergele, and Colwyn."
(With W. H. Dalton.) "Chronological List of Books and Papers relating to the Geology of Lincolnshire and East Nottinghamshire": pp. 161–176 of "The Geology of the South-West Part of Lincolnshire . . ."
1886. (With W. H. Dalton.) "The Geology of the Country around Aldborough, Framlingham, Oxford, and Woodbridge."
(With F. J. Bennett and J. H. Blake.) "The Geology of the Country between and south of Bury St. Edmunds and Newmarket."
1887. (With W. H. Dalton.) "The Geology of the Country around Halesworth and Harleston."
"List of Works on the Geology, Mining, Mineralogy, and Palæontology of Derbyshire": pp. 185–202 of "The Geology of . . . North Derbyshire."
"The Geology of Southwold and of the Suffolk Coast from Dunwich to Covehithe."

1889. "The Geology of London and of Part of the Thames Valley." 2 vols.
1891. (With H. B. Woodward and others.) "The Geology of Parts of Cambridgeshire and of Suffolk."
1893. (With S. B. J. Skertchly and others.) "The Geology of South-Western Norfolk and of Northern Cambridgeshire."
1898. (With A. Strahan.) "List of Books, Papers, Maps, etc., on the Geology, Mineralogy, and Palæontology of Dorset": pp. 241–268 of "The Geology of the Isle of Purbeck."
1899. (With A. J. Jukes-Browne.) "The Geology of the Borders of the Wash."
(With C. Reid.) "The Water Supply of Sussex from Underground Sources."
1902. "The Water Supply of Berkshire from Underground Sources," by J. H. Blake (contributions to).
"The Geology of the Country around Southampton," by C. Reid (contributions to).
1904. "The Water Supply of Lincolnshire from Underground Sources" (contributions to).
1906. "The Water Supply of Suffolk from Underground Sources."

3. Papers published in the Quarterly Journal of the Geological Society of London.

1861. "On the 'Chalk Rock,' the Topmost Bed of the Lower Chalk . . . . ": vol. xvii, pp. 166–170.
"On a Reconstructed Bed on the Top of the Chalk and Underlying the Woolwich and Reading Beds": ibid., pp. 527–528.
1862. "On the Western End of the London Basin: on the Westerly Thinning of the Lower Eocene Beds in that Basin; and on the Greywethers of Wiltshire": vol. xviii, pp. 258–274.
1865. "On the Chalk of the Isle of Thanet": vol. xxi pp. 395–398.
"On the Chalk of Buckinghamshire, and on the Totternhoe Stone": ibid., pp. 398–400.
"On the Chalk of the Isle of Wight": ibid., pp. 400–406.
1866. "On the 'Lower London Tertiaries' of Kent": vol. xxii, pp. 404–435, pl. xxii.
1869. "On the Succession of Beds in the 'New Red' on the South Coast of Devon and on the Locality of a New Specimen of *Hyperodapedon*": vol. xxv, pp. 152–158.
1871. "On the Chalk of the Southern Part of Dorset and Devon": vol. xxvii, pp. 93–100.
"On the Cliff-Sections of the Tertiary Beds west of Dieppe in Normandy, and at Newhaven in Sussex": ibid., pp. 263–268.
1874. "On the Occurrence of Thanet Beds and of Crag at Sudbury, Suffolk": vol. xxx, pp. 401–405.
1877. "Note on the Red Crag": vol. xxxiii, pp. 122–125.
1884. "Introductory Notes on the Eocene Beds." In Lieut.-Colonel Godwin-Austen's paper "On the New Railway-Cutting at Guildford": vol. xl, pp. 599–600.
1886. "On some Borings in Kent: A Contribution to the Deep-seated Geology of the London Basin": vol. xlii, pp. 26–48, pl. iii.
1887. "Further Notes on the Results of some Deep Borings in Kent": vol. xliii, pp. 197–205.
1888. ["On Specimens from the Deep Boring at Streatham"]: Proc. Geol. Soc., No. 528, pp. 9–10, and No. 529, p. 23.
1890. "On a Deep Channel of Drift in the Valley of the Cam, Essex": vol. xlvi, pp. 333–340.
1894. (With A. J. Jukes-Browne.) "On Deep Borings at Culford and Winkfield, with Notes on those at Ware and Cheshunt": vol. l, pp. 488–514.
1899. Anniversary Address of the President ("Geology in reference to Water Supply, etc.," pp. lxix–lxxxiii): vol. lv, p. liii.
1900. Anniversary Address of the President ("Underground Geology," pp. lxix–lxxxvii): vol. lvi, pp. li–lxxxviii.
1903. "On some Well-Sections in Suffolk": vol. lix, pp. 33–50.

4. *Papers published in the Proceedings of the Geologists' Association.*

1878. "Excursion to the North Downs, Surrey": vol. v, no. 8 (? 1879), pp. 495–497.
1880. "Excursion to Upnor": vol. vi, no. 7, pp. 336–337.
1883. "The Geology of the District [to be] visited during the Whitsuntide Excursion and Excursion to Hunstanton": vol. viii, pp. 124, 132–141.
1886. "Excursion to Canterbury, Reculvers, Pegwell Bay, and Richborough": vol. ix, no. 4, pp. 168–177.
1887. "Excursion to Salisbury and Stonehenge": vol. ix, no. 8, pp. 522, 531.
1888. "Easter Excursion, 1887 [Bognor, etc., and] Preliminary Excursion to Southampton": vol. x, no. 4, pp. 132–141.
"Excursion to Sudbury, Suffolk": ibid., pp. 187–191.
1889. "Whitsuntide Excursion to the Crag District": vol. xi, no. 5, pp. lxviii–lxxii.
1901. "Twelve Years of London Geology (General, Recent, and Drift)": Presidential Address, vol. xvii, pt. 2, pp. 81–109.
1902. "A Dozen Years of London Geology (Eocene, Chalk, and Underground)": Presidential Address, vol. xvii, pt. 6, pp. 342–364.
(With O. A. Shrubsole.) "Excursion to Reading": ibid., pts. 7, 8, pp. 381–383.
(With C. Bird.) "Excursion to Frindsbury and Upnor": ibid., pts. 9, 10, pp. 397–398.
1904. "Excursion to the Croydon Bourne": vol. xviii, pt. 7, pp. 388–389.
1906. "Excursion to Battle and Netherfield": vol. xix, pt. 10, pp. 449–451.

5. *Papers on Wells (by Counties) other than those in the Geological Survey Memoirs.*

1885. "Some Hertfordshire Well-Sections": Trans. Herts. N.H. Soc., vol. iii, pt. 5, pp. 173–180.
1886. "Some Surrey Wells and their Teachings: with sections of Wells and Deep Borings in the Surrey Part of the London Basin": Trans. Croydon Micr. N.H. Club, vol. iii, pp. 43–69.
"Some Essex Well-Sections": Trans. Essex Field Club, vol. iv, pt. 2, pp. 149–170.
1889. "Hampshire Well-Sections": Papers Hants. Field Club, No. iii, pp. 17–36.
"Some Essex Well-Sections" (part ii): Essex Nat., vol. iii, pp. 44–51.
1890. "Some Hertfordshire Well-Sections" (second paper): Trans. Herts. N.H. Soc., vol. vi, pt. 2, pp. 53–64.
1892. "Some Essex Well-Sections" (part iii): Essex Nat., vol. vi, pp. 47–60.
1893. (With H. B. Woodward.) "Notes of some Somerset Wells": Proc. Bath N.H. Antiq. Field Club, vol. vii, No. 4, pp. 340–345.
1895. "Some Suffolk Well-Sections": Rep. Brit. Assoc., pp. 436–440.
"Some Surrey Wells" (second paper): Trans. Croydon Micr. N.H. Club, vol. iv, pp. 132–150.
1896. "Some Essex Well-Sections" (part iv), with some Water-Analyses: Essex Nat., vol. ix, pp. 167–190.
1897. "Some Yorkshire Well-Sections": Proc. Yorksh. Geol. Soc., vol. xiii, pt. 2, pp. 192–198.
1898. "Some Middlesex Well-Sections": Trans. Brit. Assoc. Water Eng., vol. ii, pp. 76–109.
"Hampshire Well-Sections" (second paper): Papers Hants. Field Club, vol. iv, pt. 1, pp. 21–45.
1901. "Kentish Well-Sections in the Rochester District": Rochester Naturalist, vol. iii, pp. 23–27, 38–41, 55–62.
"Some Surrey Wells" (third paper): Trans. Croydon Micr. N.H. Club, vol. v, pp. 30–50.
1902. "Kentish Wells and Deep Borings in the Neighbourhood of Canterbury": S.E. Naturalist, pp. 47–60.
1905. "Well-Sections in Cambridgeshire": Rep. Brit. Assoc. for 1904, pp. 266–271.
"Some Surrey Wells" (fourth paper): Trans. Croydon Micr. N.H. Soc., vol. vi, pp. 71–85.

6. *Bibliographies, other than those in Geological Survey Memoirs.*

1870–2. "List of Works on the Geology, Mineralogy, and Palæontology of Devonshire": Trans. Devon. Assoc., pp. 330–352; Supplementary List, vol. v, pp. 404–415.

1871. "Chronological List of Books, Papers, etc., by J. Beete Jukes": in his "Letters" by his sister, pp. 591–596.

1873. "List of Works on the Geology, Mineralogy, and Palæontology of the Hampshire Basin": Journ. Winchester Sci. Lit. Soc., pp. 108–127.

"List of Books, Papers, Maps, etc., on the Geology, Mineralogy, and Palæontology of Wiltshire": Mag. Wilts. Archæol. N.H. Soc., pp. 14.

"List of Works on the Geology of Cambridgeshire": Woodwardian Museum, Cambridge, 8vo, pp. 15.

1874. "List of Books, Papers, Maps, etc., on the Geology, Mineralogy, and Palæontology of Warwickshire": Rep. Rugby School N.H. Soc. for 1873, pp. 66–76.

1875. "List of Works on the Geology, Mineralogy, and Palæontology of Cornwall": Journ. R. Inst. Cornwall, No. xvi, pp. 61–110.

1876. "List of Works on the Geology of Hertfordshire": Trans. Watford N.H. Soc., vol. i, pt. 3, pp. 78–82.

"List of Works on the Geology, Mineralogy, and Palæontology of Cheshire": Proc. Liverpool Geol. Soc., 1875–6, pp. 127–147.

1880. "List of Works on the Geology, Mineralogy, and Palæontology of Wales" (to the end of 1879): Rep. Brit. Assoc. for 1880, pp. 397–436.

1883. "List of Works on the Geology and Palæontology of Oxfordshire, of Berkshire, and of Buckinghamshire": Rep. Brit. Assoc. for 1882, pp. 327–347.

"A List of Works relating to the Geology of Cumberland and Westmoreland": Trans. Cumberland Assoc., pt. vii, pp. 15–39.

1886. "Chronological List of Works on the Coast-Changes and Shore-Deposits of England and Wales": Rep. Brit. Assoc. for 1885, pp. 442–465. Index of authors and places added in separate copies.

"List of Works on the Geology, Mineralogy, and Palæontology of Staffordshire, Worcestershire, and Warwickshire": ibid., pp. 780–815.

1888. "Chronological List of Works referring to Underground Water, England and Wales": Rep. Brit. Assoc. for 1887, pp. 384–414.

1889. (With W. W. Watts.) "List of Works on the Geology, Mineralogy, and Palæontology of Shropshire": Trans. Shropsh. Archæol. N.H. Soc., vol. xii, pt. 1, pp. 33–62.

(With W. H. Dalton.) "List of Works on the Geology, etc., of Essex": Essex Nat., vol. iii, pp. 61–84.

1895. "Second Chronological List of Works on the Coast-Changes and Shore-Deposits of England and Wales": Rep. Brit. Assoc., pp. 388–392.

"Second Chronological List of Works referring to Underground Water, England and Wales": ibid., pp. 394–402.

7. *Various Papers, etc., in various publications.*

1860. "Geology of Reading": Geologist, vol. iii, pp. 390–391.

1864. "The Tertiary Beds of Kent": Geologist, vol. vii, pp. 57–62.

1867. "Note on the Surface-Geology of London": Appendix to Report of the Medical Officer of the Privy Council, pp. 346–366, 8vo, London.

1868. "The Geology in the Report by Dr. Buchanan on the Distribution of Phthisis as affected by Dampness of Soil": Tenth Report of the Medical Officer of the Privy Council, pp. 57, etc., 8vo, London.

1877. "Some Questions relating to the Water Supply of London": Soc. Med. Off. Health, Ann. Rep., 1876–7, pp. 19–21.

"The Well-Section at Holkham Hall, Norfolk": Trans. Norwich Geol. Soc., pt. i, pp. 16–18.

1880. "The Geology of the Thames Valley": Dickens's "Dictionary of the Thames," pp. 68–72, London.

1881. "Well-Section at Stonehouse, Plymouth": Trans. Devon. Assoc., vol. xiii, p. 298.

"Geology of the District": Lynn Advertiser, Oct. 29.

1883. "On Things in general and the Red Chalk in particular" (Presidential Address): Proc. Norwich Geol. Soc., pt. vii, pp. 207–236. The greater part also in GEOL. MAG., dec. II, vol. x, pp. 22–33.

1884. "On the Probable Occurrence of Totternhoe Stone near Roydon, Norfolk": Proc. Norwich Geol. Soc., pt. viii, p. 238.

"Note on the Deep Well at the Carrow Works, Norwich (Messrs. Colman's)": ibid., pp. 250–251.

"The Work of the Year as regards Norfolk.—Some Geological Conditions affecting the Question of Water Supply from the Chalk . . . .": Proc. Norwich Geol. Soc., pt. viii, pp. 277–294. The chief part also in GEOL. MAG., dec. III, vol. i, pp. 23–29.

"On the Area of Chalk as a Source of Water Supply": Health Exhibition Literature, vol. viii, pp. 364–373, 596–597; and Journ. Soc. Arts, vol. xxxii, no. 1,653, pp. 847–851. See also Rep. Brit. Assoc. for 1884, pp. 731, 896 (1885), or GEOL. MAG., dec. III, vol. i, pp. 468–469.

1887. "Ne Sutor ultra Crepidam" (Address to Section III): Trans. San. Inst., vol. viii.

1889. "On the Extension of the Bath Oolite under London, as shown by a Deep Boring at Streatham": Rep. Brit. Assoc. for 1888, pp. 656–657.

1890. "Coal in the South-East of England": Journ. Soc. Arts, vol. xxxviii, no. 1,953, pp. 543–557.

1893. "On Maps showing the Area of Chalk available for Water Supply in the London Basin": Trans. San. Inst., vol. xiii, pp. 243–253.

"Local Geology from a Sanitary Standpoint": ibid., pp. 266–271.

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II.—On the Ashgillian Series.

By J. E. Marr, Sc.D., F.R.S.

In my Address to the Geological Society in 1905 I proposed the use of the term Ashgillian for the uppermost series of the Ordovician System, but did not discuss therein at length the exact relationship of the beds to which the term was applied, with the underlying and overlying strata. An examination of the literature treating of these rocks showed that there was a considerable amount of confusion with regard to these strata, and it is the object of this paper to clear this up and to indicate what deposits are actually referable to the Ashgillian division.

I. Historical.

In the Introduction to the "Synopsis of the Classification of the British Palæozoic Rocks" (which is undated, though a postscript is dated July 19th, 1855), Sedgwick gives the Bala Group as constituting the whole of his Upper Cambrian, while the Arenig slates and porphyries are placed in the upper division of his Middle Cambrian. He divides the Bala Group as follows:—"*a*. Lower Bala rocks. (1) A great series of dark and sometimes earthy slate. (2) A great series of slates, flags, and grits, ascending to the Bala Limestone.—*b*. Upper Bala rocks. Under this term are included: (1) The Bala and Hirnant Limestone and the Llandeilo calcareous flag. (2) Flagstones, slates, calcareous beds, and shelly sandstones of Caer Caradoc. The whole series ending, in North Wales, with slate and flagstone; and, in South Wales, with slates, grits, and coarse conglomerates. The group of very great thickness."

In this scheme the term Upper Bala was used in a wider sense than that in which it was subsequently used by Salter with Sedgwick's consent.

In "The Catalogue of the Collection of Cambrian and Silurian Fossils in the Geological Collection of the University of Cambridge," published by the University Press in 1873, the term "Upper Bala" was restricted, and a new term "Middle Bala" introduced and adopted "for the Bala Limestone and its associated sandstones and slates, several thousand feet thick in N. Wales . . . . ."

On p. 39 of the Catalogue the following is given as the extent of the Middle Bala Group: "Professor Sedgwick only includes in this group the 9,000 feet of beds, chiefly arenaceous, slaty, and with some calcareous bands, which lie over the dark earthy slates of the Arenig section (Lower Bala). The group extends a short distance, probably a couple of hundred feet, above the Bala Limestone. But it does not include the Hirnant Limestone, which is the base of the Upper Bala group next described. It appears to represent in mass the whole of the Caradoc Sandstone proper, in Shropshire."

We here find a definite statement that the Hirnant Limestone is the base of the Upper Bala Group.

On pp. 72–83 the Upper Bala fossils are catalogued, and at the head of p. 72 the following grouping is given:—

"Upper Bala Group, Sedgw. (restricted in 1866). The Upper Bala of the synopsis includes the Bala Limestone, now *Middle Cambrian*.[1]

"1. *Hirnant Limestone* and Llanfyllin Beds, viz., pale-coloured slates above the Bala Limestone. Ash Gill slates, etc., above the *Coniston Limestone*.

"2. *Llandovery Rocks* (Phillips, Salter, Lyell—*Lower Llandovery* of the Survey)."

The same classification is given in somewhat different words on p. 26 (text).

With regard to the restriction of the term in 1866 I have searched in vain for any printed record of such restriction, and believe that it was the result of conversation between Sedgwick and Salter, for in a note on p. 26 of the Catalogue Salter writes: "Prof. Sedgwick trusts me to arrange them [the Bala fossils] according to the present state of our knowledge, 1867. The Bala Group or Upper Cambrian of Sedgwick therefore consists of:—

Upper Cambrian (Sedg.).
- Lower Bala = Llandeilo Flag (*Upper Llandeilo*, Geol. Survey, the Arenig being the lower).
- Middle Bala = Caradoc Sandstone and Bala rocks (Geol. Survey and Sir R. I. Murchison).
- Upper Bala = Caradoc shales, Hirnant Limestone, and Lower Llandovery rock (Geol. Survey)."

It is clear to me that the Upper Bala as defined by Salter in the paragraph I have quoted is very different from the Ashgillian as I propose to use it, so far as the Bala region is concerned, for he definitely takes the base of the Hirnant Limestone for its base, whereas I propose to include beds some way below this limestone, which beds, I hope to show, are equivalent to the Ashgill Beds, which Salter includes in the Upper Bala.

The position of the summit of the Upper Bala Group as defined by Salter is even more unsatisfactory. We have seen that he divides the Upper Bala Group into two sub-groups, viz., the Hirnant Limestone, etc., below, and the Llandovery above.

Salter himself says of them (Cat. Camb. and Sil. Foss., p. 72): "The fossils of these two divisions are arranged together, as it is clearly impossible always to draw a line between them; they form, indeed, one series. But the list is kept in *two separate columns here*, as each group contains a few peculiar species."

The Llandovery Beds here mentioned (now called Lower Llandovery) are at the present day, by general consent, bracketed with the May Hill Beds (Upper Llandovery) to form the basal series of the Silurian system. We are therefore concerned with the rocks containing the fossils placed by Salter in the columns of the Catalogue headed "Upper Bala proper." Twenty-two forms are recorded in these columns. The first entry, *Nidulites favus*, is clearly placed in the wrong column owing to a clerical error. Two trilobites are given, viz. *Phacops obtusicaudatus* and *Proetus* sp., from Coldwell and the equivalent strata of Helm(s) Knot, Dent. Salter elsewhere (Cat., p. 26) brackets these Coldwell Beds with the Ashgill Beds—an extraordinary error, the Coldwell Beds actually belonging to the Lower Ludlow

[1] The word Cambrian is clearly a misprint for Bala.

Group. We are left with 19 forms, viz.: 2 Corals, 2 Bryozoa, and 15 Brachiopods, of which 11 are *Orthides*, most of which have a long range. This attempted definition of the "Upper Bala proper" by its included fauna is almost as unsatisfactory as the attempt to draw definite lines at its base and summit. The one satisfactory determination in the Catalogue is that of the position of the Ashgill Beds.[1]

Having now considered the "Upper Bala" Group as originally defined in the Cat. Camb. and Sil. Foss., we may pass to the consideration of other contributions to the study of the highest Ordovician strata at home and abroad.

The British area where the Ashgillian rocks were first accurately separated from those of Middle Bala (Caradocian) age was, as has been already stated, that of Lakeland, and we may now consider the work which has been done in that region.

The Upper Bala Beds of the Lake District proper, unlike those of Wales, have from the time of the restriction of the term in 1866 been correctly grouped, save that Salter included the Coldwell Beds (of Lower Ludlow age) with the Ashgill Beds proper, but his reference of the Ashgill Beds to the Upper Bala showed that these beds were recognised by him as separable from the Middle Bala Group.

Professor T. McK. Hughes in 1876 showed me that the shales of the Sedbergh area, which he spoke of as the "Fairygill Shales," were, like the Ashgill Shales, distinguishable from the "Coniston Limestone" below (which contains a Middle Bala fauna) by their organic contents, and he discovered *Strophomena* (?) *siluriana* in the Ashgill Shales of Ashgill, he and the Rev. H. G. Day having previously found it in Fairygill, etc., and sent specimens to Davidson, who described them in the monograph on the Brachiopods published by the Palæontographical Society in 1870. Professor Hughes never published his views, but to him belongs the credit of showing that Salter's Ashgill Beds were more than a local development of beds at Ashgill.[2]

In a paper which appeared in the Quarterly Journal in 1878 I gave a short list of fossils from the Ashgill Shales, but at that time had not recognised a calcareous deposit below the base as belonging to the Ashgill Group. I first referred that limestone to the Ashgill Series in my Sedgwick Essay (1883) in the following words:—

"*Upper Bala Series.* The Ashgill Shales of Sedgwick and Salter succeed the Coniston Limestone, and have a very different fauna. They are never more than 200 feet thick, and consist of a lower stage of grey crystalline limestone, succeeded by poorly cleaved bluish or blackish shales." Then follows a list of fossils, of which those occurring in the lower (calcareous) stage are marked by

[1] I have found it necessary to criticise adversely some of Salter's conclusions. It is only fair to state that at the time when the Cat. Camb. and Sil. Foss. was compiled he was in deplorable health; also that he was unacquainted with the rocks in the field whose fossils he was arranging and cataloguing. I need hardly mention the respect I have for the work he did among the Lower Palæozoic fossils.

[2] There is reason to believe that the name Ashgill Beds was originally suggested to Salter by Aveline, who separated them from the "Coniston Limestone" proper: at any rate, Salter proved the distinctness of the two groups on palæontological grounds.

an asterisk. Among these are *Caryocystites Davisii* and *Staurocephalus clavifrons*. As both limestone and shales are developed in the quarry of the typical locality, Ashgill, it seems peculiarly appropriate, in the absence of any accurate definition of the limits of the so-called Upper Bala Beds, to use the name of this locality in connection with the division, as I suggested in my Address to the Geological Society in 1905.

In 1892 (Geol. Mag., Dec. III, Vol. IX, p. 97) I published a paper on "The Coniston Limestone Series." In this paper separate lists of the *Staurocephalus* Limestone and Ashgill Shale divisions of the Ashgillian are given, but the Keisley Limestone fossils are wrongly placed with the Caradocian fossils of the Sleddale group.

The true age of this Keisley Limestone was proved by Mr. F. R. Cowper Reed.[1] In his two papers on this limestone he shows that its fauna appertains to the Upper Bala (Ashgillian), and not to the Middle Bala (Caradocian).

Last year I was able to show that the *Staurocephalus* Limestone of the Cross Fell Inlier, previously described by Professor Nicholson and myself, was *in* the Keisley Limestone and not *above* it as we had wrongly concluded. The Ashgillian Beds of the North of England are therefore separable into two divisions—

Ashgill Shales.
Staurocephalus Limestone (with Keisley Limestone).

Turning now to South Wales, we find the most satisfactory development of Ashgillian Beds, so far as Britain is concerned, in that area. These beds were classified and described by the late Mr. T. Roberts and myself in 1885 in a paper in the Quarterly Journal of the Geological Society (vol. xli, p. 476). We divided the beds as follows:—

Slade Calcareous Shales.
Redhill Shales.
Sholeshook Limestone.

We also showed that the Sholeshook Limestone was comparable with the *Staurocephalus* Limestone of Lakeland, the Rhiwlas Limestone of the Bala area, and other deposits elsewhere, and that the Redhill Beds were comparable with the Ashgill Shales. The Slade Beds presented lithological characters differing from those of other known areas possessing Ashgillian rocks, and there is still some uncertainty concerning their equivalents elsewhere, and accordingly we are yet uncertain as to the precise position of the line marking the top of the Ashgillian Beds of some districts. To this point I shall recur later.

In this paper sufficient fossil lists were given to show the marked difference between the fauna of the Caradoc Beds and that of the overlying Ordovician strata, and the latter were shown to be widely spread in the British Isles and to be represented by beds containing similar faunas on the Continent, although the equivalence of some of the Scandinavian beds with the beds of Ashgill had previously been asserted by one of the authors and likewise by Dr. S. L. Törnquist.

[1] Q.J.G.S., vol. lii, p. 407, and vol. liii, p. 67.

The distinctness of the Caradocian and Ashgillian Series, over wide areas, as based upon lithological characters and faunas, was thus for the first time clearly brought out, and a fairly definite base and summit for the series which I here speak of as Ashgillian was determined. The Ashgillian Series was, in fact, here clearly described as a group worthy of separation from the Caradocian series beneath.

Our classification of these South Welsh deposits has subsequently been confirmed by the officers of the Geological Survey, and later by Mr. D. C. Evans in an admirable paper on the Ordovician of Western Caermarthenshire.[1]

Let us return for a moment to North Wales. The fossils of the Rhiwlas Limestone undoubtedly show its relationship to the Sholeshook and *Staurocephalus* Limestones, and prove its distinction from the Bala Limestone of Caradocian age. This distinction, as I stated in my Presidential Address in 1905, was clearly suspected by a member of the Geological Survey in 1847.

In that address I divided the Ashgillian Beds of North Wales as follows:—

Hirnant Limestone.
Shales.
Rhiwlas Limestone.

There is still much work to be done among these North Welsh rocks. In 1880[2] I referred a calcareous grit with *Echinosphærites*, "by the roadside about a quarter of a mile south-west of Maeshir," to the "Upper Bala Beds." This is probably correct, but a further reference of the *Orthis alternata* beds of Cerrig-y-druidron to this series is almost certainly an error.

When the Ashgillian Beds of this region are eventually defined the definition will undoubtedly be facilitated in consequence of Mr. T. Ruddy's paper on the area.[3] It is quite clear that some of the rocks described by Mr. Ruddy belong to the Ashgillian division. Miss Wood (Mrs. Shakespear) and Miss Elles have obtained undoubted Ashgill Shales with *Phacops mucronatus* near Conway (Q.J.G.S., vol. liii, p. 273).

As in the case of South Wales, so here, we are in difficulty as to the precise position of the upper limit of the Ashgillian strata.

In 1882[4] Professor Lapworth described the Girvan succession in Ayrshire. At the top of the Ordovician system he places the Drummuck Mudstones, with the following subdivisions:—

Upper Mudstones, Ladybarn.
Starfish Band, Quarrel Hill.
Lower Mudstones, Drummuck.
Basal Sandstones, Auld Thorns.

In our paper on Haverfordwest Mr. Roberts and I remarked that "the Starfish Bed of Professor Lapworth . . . . may possibly be the representative of this [Sholeshook Limestone] in the Girvan area. It also contains *Staurocephalus globiceps*." There is very little

[1] Q.J.G.S., vol. lxii (1906), p. 597.
[2] Q.J.G.S., vol. xxxvi (1880), p. 277.
[3] Q.J.G.S., vol. xxxv (1879), p. 200.
[4] Q.J.G.S., vol. xxxviii (1882), p. 537.

doubt as to the correctness of this correlation, in which case the overlying Ladyburn Mudstones are the probable equivalents of the Ashgill Shales.

It must be borne in mind that as there is stratigraphical conformity between the Ordovician Hartfell Shales and Silurian Birkhill Shales of the Moffat area, the uppermost portion of the graptolite-bearing Hartfell Shales must also be referable to the Ashgillian Series.

In Ireland beds of Ashgillian age have been detected in various parts.

In 1896 Messrs. Gardiner & Reynolds[1] described the limestone of the Chair of Kildare, which with previous writers they refer to the Coniston Limestone, and in 1897 the same authors[2] describe, among other rocks, the Portraine Limestone, and state that it is comparable to the Chair of Kildare Limestone on the one hand and on the other to the Keisley and Sholeshook Limestones of Great Britain. Each of these deposits, therefore, belongs to the Ashgillian Series.

But the most interesting Irish development of Ashgillian age is found near Pomeroy. The fauna of these rocks has long been known, having been described in 1863 in Portlock's "Report on the Geology of . . . Londonderry . . . Tyrone, and Fermanagh."

In our paper on Haverfordwest Mr. Roberts and I state that the group of fossils characteristic of the Sholeshook Limestone "appears to occur at Desertcreat [e], Tyrone," and we enumerate species common to the South Welsh and Irish areas, and state that fossils from the Irish locality seem to show that the representatives of the Redhill stage occur there also.

Recently this tract has been studied by a party of Cambridge geologists, and an outline of their results has been published in the Geological Magazine by Mr. W. G. Fearnsides.[3] The beds referred to the Ashgillian Series are there spoken of as the Desertcreate Group. It shows the Drummuck facies, and the point of particular interest is the discovery of graptolites of Upper Hartfell age associated with fossils characteristic of the non-graptolitic facies of Ashgillian deposits. The subdivisions of the Desertcreate Group will be found on p. 422 of Mr. Fearnsides' notice, and need not be repeated here.

Abroad the representations of the Ashgillian Series are known only in Scandinavia and Russia. In 1879 S. L. Törnquist,[4] who had examined my specimens of Ashgill fossils and afterwards was taken over the Lake District section by my brother, correlated the Ashgill Shales with the 'Brachiopod-schists' of Sweden, and in 1882[5] I pointed out that they were comparable with the lower part only of these Brachiopod-schists. Later in our Haverfordwest paper Mr. Roberts and I showed that both *Staurocephalus* Limestone and Ashgill Shales were represented in Sweden.

The *Leptæna* Limestone of Dalarne has been referred to various horizons, but Schmidt's work in the Baltic provinces has shown that it is clearly equivalent to stage F of Russia, and it must therefore be

[1] Q.J.G.S., vol. lii, p. 587.
[2] Q.J.G.S., vol. liii, p. 520.
[3] Geol. Mag., Dec. V, Vol. III, p. 421.
[4] Öfv. af k. Vetensk. Akad. Förhandl., p. 63.
[5] Q.J.G.S., vol. xxxviii, p. 313.

intermediate in age between the *Trinucleus* Shales and the *Lobiferus* Beds of Dalarne, the former being of Caradocian and the latter of Birkhillian age. The general correspondence of its fauna with that of the Ashgillian Beds of Britain indicates its general Ashgillian age, but there are certain differences which suggest that beds of other ages are also represented in the *Leptæna* Limestone.

II. Lithological Characters.

There is a striking similarity in the lithological characters of some of the deposits of Ashgillian age over wide areas. Leaving out of account the Slade Beds of South Wales and certain deposits which in other areas are doubtfully Ashgillian, we find a widespread distribution of lower calcareous and upper argillaceous strata. The calcareous division in Cumberland, Wales, parts of Scandinavia, and probably elsewhere is marked by a greyish, somewhat argillaceous limestone with calcareous shales, each weathering olive-green. With these are purer white limestones, which often assume a markedly crystalline character, as at Keisley and the Chair of Kildare. The overlying argillaceous beds are often bluish-grey and not very markedly laminated sandstones. There is a very decided resemblance between these mudstones as found in the Lake District, North Wales (Conway), South Wales, and in parts of Sweden.

III. Fossils.

The fauna of the Ashgillian Beds is very rich, but comparatively little is yet known of it. When the fossils have been collected as assiduously as those of the Chalk (for instance) we shall probably find a marked contrast between the fauna of the Ashgillian Series and those of the Caradocian below and Valentian (Llandovery-Tarannon) above.

In the present state of our knowledge a few notes on the dominant characters of the fossils may be of use to future students of these beds.

In Lakeland and South Wales the abundance and variety of Cystidea is very noteworthy. These fossils are specially found in the *Staurocephalus* Limestone of the northern area and in the Sholeshook Limestone of the Principality. Cystidea of course have a long range, but some of those found in the Ashgillian Limestones are probably characteristic forms. They appear, however, to be local: for example, I am not aware of any record of these organisms in the Desertcreate Beds.

It has been noted above that *Strophomena* (?) *siluriana* is characteristic of the Ashgillian Beds of the North of England. It is still doubtful if this form and *Orthis hirnantensis* of the Hirnant Limestone are specifically distinct. At present we are only able to use the so-called *Strophomena* locally.

The Slade Beds of Haverfordwest are often crowded with *Phyllopora Hisingeri*. The occurrence of this form in the upper part of the Ashgill Beds of Backside Beck, near Sedbergh, is of significance. The latter beds are worthy of more careful examination.[1]

[1] See Marr & Nicholson on "The Stockdale Shales": Q.J.G.S., vol. xliv, p. 700.

The trilobites have up to the present received most attention. By means of these Crustaceans we can most readily separate the Ashgillian Beds from those of Caradocian and Valentian ages.

The occurrence of *Staurocephalus* in the lower part of the Ashgillian Series and of *Dalmannites mucronatus* in the upper part (and also in the lower) has frequently been noted. A few remarks upon each of these forms will be useful.

The term *Staurocephalus* Beds was first applied to rocks belonging to the Ashgillian age in Sweden and subsequently in Britain. The Swedish form is *Staurocephalus clavifrons*, Ang. *Staurocephalus globiceps*, Portl., is probably identical with the Swedish form. Lastly, Salter (Mon. Pal. Tril., pl. vii) figures a form from Rhiwlas as *Staurocephalus Murchisoni*, Barr. It may be noted that Barrande's type form is from beds of Ludlow age. It is doubtful whether even the British Wenlock forms which are referred to this species are correctly assigned, and there are grave doubts as to the identity of the Bohemian and Rhiwlas forms. The Ashgillian *Staurocephali* require careful study, and the three forms above noted will probably prove to be identical or closely allied, and separable from the Wenlock and Ludlow fossils.

The genus, if found in Caradoc rocks, is extremely rare therein. It is also far from common in rocks of Valentian age, and its wide distribution in the Ashgillian Beds is distinctly noteworthy.

Dalmannites mucronatus, Ang., is particularly abundant in beds of Ashgillian age, and is very useful when separating them from the Caradocian deposits, in which, so far as I am aware, it has not been found. On the other hand, it passes up into the Valentian rocks, both in Britain and in Scandinavia, and forms one of the few connecting links of the Ordovician and Silurian faunas.

This form requires study. Angelin describes two species, namely, *Dalmannites mucronatus*, which in Sweden is a Valentian form, and *D. eucentra*, which occurs in the equivalents of the Ashgill Shales. Salter also separated the North of England form from the type *mucronatus* as var. *appendiculatus*. Later writers have referred all to *mucronatus*, and if the Ashgillian and Valentian forms be distinct they are certainly closely allied.

While speaking of the *Phacopes*, we may note that the group *Chasmops*, so abundant in rocks of Caradocian age, appears to be absent from the Ashgillian Beds, and that the group *Phacops* proper, which is found abundantly in the overlying Valentian rocks, has also never been recorded from beds of Ashgillian age.

Turning now to the genus *Trinucleus*, we find that this form, so abundant in all Ordovician rocks, is well represented in the highest Ashgillian Series. The sudden disappearance of this form at the top of the Ashgillian Beds is one of the most important means of separating these from the Lower Valentian (Llandovery) Beds. It is true that *Trinucleus* has been more than once recorded in beds of Llandovery age, but even if these records be correct the genus is *extremely* rare in them. Let us for a moment notice these records.

In Cat. Camb. and Sil. Foss., p. 78, Salter records *T. concentricus* from the Lower Llandovery of Pen-y-craig. I find the actual

specimen now placed among the Caradocian fossils in the Sedgwick Museum, on whose authority I cannot say, but Professor Hughes, who knows the district well, assures me that at the time of this determination considerable confusion existed as to the age of the various beds there.

There are various references to the occurrence of *Trinucleus* in both Lower and Upper Llandovery rocks in the Mem. Geol. Survey, vol. iii (3rd edition, 1881), but the information given is of the vaguest, and I cannot help suspecting mistakes.

In 1877 Professor Harkness & Nicholson gave in the Quarterly Journal of the Geological Society a list of trilobites from the Stockdale Shales. In this was included *Trinucleus fimbriatus*, a determination which Professor Nicholson subsequently admitted to be founded on error, and accordingly the species was not recorded in the later paper on those shales by Professor Nicholson and myself.

On the Continent one example of *Trinucleus Wahlenbergi* is recorded in Kjerulf's "Veiviser" from stage 5 (of Llandovery age). It occurred in a nodule, and may possibly be derivative.

In any case the extreme rarity of the genus in the Valentian rocks is in marked contrast to its abundance in even the highest (Slade) stage of the Ashgillian Beds, though it must not be supposed that *Trinucleus* is common or even represented in all Ashgillian strata; it is, for example, distinctly rare in those of most localities in the North of England.

Of trilobite species which, so far as I know, are confined to Ashgillian rocks, I may mention *Encrinurus sex-costatus*, *Cheirurus octolobatus*, *Cyphoniscus socialis*, *Remopleurides longicostatus*, and *Ampyx tumidus*. There are many others which have hitherto been found in one or two localities only.

Several forms which occur rarely in Caradoc rocks are more abundant in the Ashgillian strata, as *Acaste Bronguiarti*, *Agnostus tumidus*, and *Phillipsinella parabola*.

The graptolites found at Dercertcreate will enable us to compare those rocks with their graptolite equivalents in the Moffat area. As, however, the work is being done by Mr. Fearnsides and his colleagues, we must await the publication of their full results.

The following lists of fossils will be useful to students of the Ashgillian rocks at home and abroad:—

Mem. Geol. Survey, Catalogue of Lower Palæozoic Fossils in the Museum of Practical Geology (1878). In this list the specimens recorded as from "Rhiwlas" are, I believe, in all cases from the *Staurocephalus* Limestone. The various papers alluded to above mostly have fossil lists. In the paper by myself on "The Coniston Limestone," the Keisley species, as above stated, belong to the Ashgillian, and not, as there recorded, to the Caradocian. A full list of the Keisley fauna is given in Mr. Reed's papers on the Keisley Limestone. The South Welsh forms are recorded in the paper by Mr. Roberts and myself, and in that by Mr. Evans. Irish forms of Ashgillian age are noticed in Messrs. Gardiner & Reynolds' papers, and in the brief notice of the Pomeroy Beds by Mr. Fearnsides. A few Scotch forms are mentioned in Prof. Lapworth's Girvan paper.

In Scandinavia we find records of fossils from the Brachiopod-schists in Linnarsson's account of the Cambrian and Silurian Beds of Westrogothia (K. Svensk. Vetensk.-Akad. Förhandl., Bd. viii. No. 2; in this paper some of the forms are apparently from the Upper Brachiopod schists, of Llandovery age); and also in Tullberg's papers on the Scanian graptolites (Svensk. Geol. Undersökn. series C, No. 50, p. 17), in the zones of *Staurocephalus clavifrons* and *Phacops mucronata*. Records of fossils of the *Leptæna* Limestone will be found in various papers by Tornquist, especially in a paper on the Palæozoic rocks of the Siljan district (Öfvers. af k. Vetensk.-Akad. Förhandl., 1874); and another on the trilobite fauna of the Siljan district (Sver. Geol. Undersökn, 1884); also in Angelin's "Palæontologia Scandinavica" and in Lindström's "Fragmenta Silurica."

A list of Russian fossils from Stage F will be found in the first part of Schmidt's "Revision der Ostbaltischen Silurischen Trilobiten" (Mem. l'Acad. Imp. des Sciences de St. Pétersbourg, 1881).

The above list is no doubt far from complete, but the student may obtain from a perusal of these papers a good idea of the varied character of the Ashgillian fauna.

IV. The Base and Summit of the Ashgillian Series.

(1) *Base*. In South Wales, where the Ashgillian succession is so well shown, the line of demarcation between the Robeston Wathen Limestone of Caradocian age and the Ashgillian Sholeshook Limestone is usually easily determinable. Although each is a limestone, they are fairly readily separable by lithological characters, and the change in fauna is very marked. Similarly, in the Lake District the change from the Caradocian Sleddale Limestone and the Ashgillian *Staurocephalus* Limestone is usually well marked, though it is possible that in the fossil lists some forms referred to the Caradocian division really belong to that of the Ashgillian. In the Cross Fell Inlier the difference between the equivalent of the Sleddale Group (Dufton Shales) and the Ashgillian Limestones is most obvious. The exact base of the Ashgillian group at Girvan yet remains to be fixed, and, as before stated, much remains to be done in North Wales.

(2) *Summit*. The line of demarcation between the Ashgillian and Valentian is usually less readily determinable than that at the base of the former series. The difficulty was admitted by Salter when he bracketed the Lower Llandovery and Upper Bala Groups (Cat. Camb. and Sil. Foss.).

There are two causes of difficulty; one the frequent similarity between the Ashgillian and Llandovery rocks, and the other the difference of opinion as to what line should be taken as marking the top of the Ashgillian. With regard to the former, the Ashgillian and Llandovery Beds of the Haverfordwest region have a striking similarity, though separated by a conglomerate, and in Scandinavia the line of demarcation must be drawn in the middle of the Brachiopod-schists.

I believe that the fossils will usually furnish a ready means of distinction. The practical disappearance of *Trinucleus* at the top of the Ashgillian has already been noted, and, so far as I know, the genera *Nidulites*, *Phacops* (proper), and *Stricklandinia* are not found below the Lower Llandovery.

The difference of opinion as to what line should be taken as separating the Ordovician from the Silurian requires fuller consideration. Professor Lapworth in the Moffat district places the lowest zone of the Birkhill Shales, that of *Diplograptus* (*Cephalograptus*) *acuminatus*, in the Silurian, while Tullberg assigns the corresponding zone in Scania to the Ordovician, because it, like the Scotch zone, has no *Monograpti*. Lithologically and palæontologically, however, it seems to be more closely related to the overlying beds than to those beneath it, and I would follow Lapworth in assigning it to the Silurian.

In North Wales the question is not so easy. The Hirnant Limestone is not a richly fossiliferous deposit, its most frequent fossil being *Orthis hirnantensis*. Salter, as we have seen, referred it to the Upper Bala, while Professor Hughes has maintained that two deposits have been referred to this division, the lower of which is Ashgillian and the upper Llandovery. The question remains to be settled.

It may be remarked that the Llandovery Beds of Wales and the Welsh borders still require much work. Professor Hughes has separated the fossils of the Upper and Lower Llandovery Beds of the typical area, and his collections are preserved in the Sedgwick Museum, but his observations require extension in surrounding areas.

My objects in this paper have been to show that the Ashgillian Beds form a group sufficiently important to be separated as a series from the beds of the Caradocian Series below; to prove that the term Upper Bala applied by Salter was too vaguely defined to stand (even were the term not objectionable on other grounds), and that therefore another term is required, that of Ashgillian being adopted because the term "Ashgill Beds" used by Salter for his Upper Bala Beds in the Lake District was applied to a definite group well defined by him; lastly, to indicate to future workers the lines on which to proceed in giving us what we greatly require, a monograph upon the stratigraphy and palæontology of this important series.

Table of the Ashgillian Strata of the British Isles.

South Wales.	North Wales.	N. of England.	Girvan.	Ireland.
Slade Beds.	Hirnant Limestone?	*Phyllograpsus*-Beds of Backside Beck, Sedbergh?	?	?
Redhill Beds.	*Mucronatus*-Beds of Conway. = Shales near Maeshir?	Ashgill Shales.	Ladyburn Shales.	Tirnaskea Beds.
Sholeshook Limestone.	Rhiwlas Limestone.	*Staurocephalus*-Limestone (with Keisley Limestone).	Starfish Bed.	Killey Bridge and Bardahessiagh Beds. = Chair of Kildare Limestone. = Portrane Limestone.

III. — Notes on the Faunal Succession in the Carboniferous Limestone of Westmoreland and Neighbouring Portions of Lancashire and Yorkshire.

By E. J. Garwood, M.A., Sec. G.S.,
Professor of Geology in University College, London.

In August last, at the meeting of the British Association at York, I gave a general account of the zonal succession of the Carboniferous Limestone as developed in Westmoreland and North Lancashire, and I instituted a comparison with beds of a similar age in the Ingleborough and North Pennine districts.

In response to a request made at the meeting, I drew up a table in which a provisional correlation was attempted with the zones of the Avonian Succession. I had not then, however, had the opportunity of consulting Dr. Vaughan regarding his most recent conclusion, the correlation with the Avonian Succession being based on the tables accompanying his paper and that of Mr. Sibley on the Mendip area.

I hope shortly to describe the Northern Succession more fully, but meanwhile I take the opportunity afforded by the courtesy of the Editor of the Geological Magazine to bring forward the problems involved in any correlation of the northern areas more fully than could be done in the short abstract published by the Association, and to revise the attempted correlation of the lower beds with Dr. Vaughan's zones.

The key to the northern area lies in the *Michelinea megastoma* bed as developed in the Arnside section, where it contains a rich fauna. This bed, together with the underlying Meathop Limestones, I have long considered to lie near the base of the succession in the north, but its relation to the Shap and Ravenstonedale Limestones and the overlying Ashfell Beds was not absolutely clear, on account of the absence of the *Michelinea* bed from the eastern exposures. The lowest bed at Arnside contains amongst others the following characteristic forms :—

Michelinea megastoma.
Zaphrentis aff. *cornucopiæ.*
Cavinia cylindrica.
Productus aff. *punctatus.*
Orthotetes crenistria.
Athyris expansa.
Chonetes cf. *comoides.*

In addition a very characteristic *Cyathophyllum* occurs in which the septa show a marked Zaphrentid type of grouping, and a new species of *Clisiophyllum*, which Dr. Vaughan has since told me he is about to describe from the basement bed at Horton, where it also occurs.

Dr. Vaughan agrees with me that this fauna points to a position near the top of his C zone in the Bristol area. No Lithostrotions occur in the *Chonetes* bed, but immediately above, in the overlying Black Limestone of Blackstone Point, they occur in abundance, together with *Diphyphyllum* and Campophyllids, and I therefore take the Blackstone Point Beds as representing the base of S_1.

These beds can be traced for a mile or two in an easterly direction, and reappear again near the base of the Scout Scar section, both in the Brigsteer and Underbarrow road cuttings (Barrowfield Beds of the table).

In the Brigsteer section occur all the species characteristic of the Arnside Beds, including the giant *Chonetes* cf. *comoides* and unusually large specimens of *Orthotetes crenistria*, neither of which occurs above this horizon in any section I have examined in the north. Indeed, the greater part of the fauna of the bed is strictly limited to this horizon, and nearly the same association occurs at the base of the Ingleborough succession,[1] and undoubtedly represents the same horizon.

Any beds, therefore, below these are of special interest, as they carry us well down into C or lower. Such beds occur at Low Meathop, opposite Arnside, and at Crag Mollet in the Brigsteer section; in both places they consist of purple dolomitic limestone, and contain fine silicified specimens of *Syringopora* (cf. *reticulata*) and small Cyathophyllids and Seminulas, while at the base at Crag Mollet occurs a bed marked by clusters of *Diphyphyllum pseudo-vermiculare* (McCoy).

If this Diphyphyllid *Lithostrotion* is to be considered typical of (S), then the whole of the Arnside Beds and the Horton Beds will have to be included in (S) also. It is possible, however, that we have here the forerunner of the *Lithostrotion* fauna, which becomes so characteristic of the *Seminula* zone above.

In the Shap and Ravenstonedale district further east the *megastoma* bed is absent, but the same purple dolomitized limestones with *Syringopora* occur towards the base, though they are here much thicker and include lower beds than any found at Kendal or Meathop, so that at Ravenstonedale we probably have the lowest beds found anywhere in the district. The absence of the *megastoma* bed makes the sequence rather more difficult to subdivide, but as the result of many years' work in the district I have come to the conclusion that this bed is represented in the Shap area by the sandstone near the base of the Ashfell series.

The evidence on which I rely is as follows:—At Brigsteer, immediately beneath the *Michelinea* bed, we have the Crag Mollet Bed full of *Diphyphyllum pseudo-vermiculare*, which, as far as I am aware, has not been found elsewhere at any higher horizon. The same form occurs abundantly near the top of the Shap-Ravenstonedale Limestone near the base of the Ashfell group, so that the latter should include the *megastoma* bed.

Again, the base of the Knipe Scar or Melmerby Limestone, resting on the Ashfell Beds, is crowded with silicified specimens of *Cyrtina carbonaria*, a form characteristic in the western area of the base of the upper *Seminula* zone[2]; furthermore, in the Shap section at the base of the Ashfell series, occurs a thin layer enclosing remains of *Camarophoria isorhyncha*, a form characteristic of the very base of the lower *Seminula* zone.[3]

Lastly, at Kettlewall, on the east side of the Kendal outlier, we have an epitome of the sequence in both areas. Here the *megastoma* bed, very much reduced in thickness, is overlain a few feet above by

[1] See Cosmo Johns & Vaughan: GEOL. MAG., 1906.
[2] Dr. Vaughan: Q.J.G.S., vol. lxi, p. 254, footnote.
[3] T. F. Sibly: op. cit., vol. lxii, p. 376.

a limestone containing *Cyrtina carbonaria* (the locality whence the type-specimens figured by McCoy and Davidson were obtained), and it has already been shown that the bed containing *Diphyphyllum pseudo-vermiculare* underlies the *megastoma* bed on the west side of this outlier. It seems, therefore, practically certain that the Ashfell Sandstone, with its included limestones, represents the whole of the lower *Seminula* zone, and that the *megastoma* bed is represented by the very top of the Shap-Ravenstonedale limestone or the base of the Ashfell group.

This fact is of great interest outside the question of local correlation of these northern exposures, as it shows that in the northern area we have a marked upheaval producing shallow-water conditions at the top of the Tournasian and base of the Visean times, similar to that recorded from the south-west province, the Ingleborough district, and elsewhere, resulting possibly even in contemporaneous erosion in some places.

With regard to the age of the lowest beds at Shap Abbey and Ravenstonedale, it is difficult to speak with certainty here. I was at first inclined to place the lowest beds at Ravenstonedale as low as Dr. Vaughan's *Cleistopora* zone, on account of the occurrence of a flat encrusting coral resembling *Cleistopora*, but Dr. Vaughan informs me this is not his typical form, and as this may not be a *Cleistopora* I have taken *Athyris glabristria* and *Spirifer* aff. *clathratus*[1] as characteristic forms for these lower beds. The latter occurs throughout the lowest beds,[2] but is specially abundant at the base, the former being plentiful near the bottom of the Shap-Ravenstonedale Limestone, while this limestone, as stated above, is everywhere characterized by a fine *Syringopora*. As *Spirifer* aff. *clathratus* occurs throughout Z and K in the Bristol area, and as corals also occur, which, though badly preserved, appear to resemble *Zaphrentis Phillipsii*, I have provisionally assigned the lowest beds in the Ravenstonedale district to the *Zaphrentis* zone of the Avon district.

The Shap Abbey Beds do not appear to include these lowest beds, and although they are rich in *Athyris glabristria* and also contain a species of *Spiriferina* and Modioliform lamellibranchs, they will probably not be found to represent beds much below the base of the C zone of Dr. Vaughan.

The correlation of the higher beds in the table does not call for much comment here. The presence of *Lonsdaleia floriformis* and *Petalaxis Portlocki* at Humphrey Head together with *Dibunophyllum* aff. *γ* at Grange, shows, that the upper *Dibunophyllum* beds are represented in the western extension of the district, and that a fault occupies the Kent estuary, bringing the lowest beds at Meathop against the highest beds at Grange. The same association of forms at Outscar, Bampton, and elsewhere, shows, that these upper beds are also present in the Shap district, and the beds below contain a typical lower *Dibunophyllum* fauna with *Cyathophyllum Murchisoni* and *Alveolites septosus* and characteristic *Productí*.

[1] Kindly determined for me by Dr. Vaughan.
[2] Lower Limestone Shales of the Government Map.

De Vaughan's Zones	Sub-zones suggested for Westmoreland and West Yorkshire.	Shap District.	Ravenstonedale.	Arnside Grange District.	Kendal.	Northern Pennines.	Ingleborough and Pexygent.
D_3	*Productus* cf. *Edelburgensis*.	...	...	...	...	...	Upper Scar Limestone.
D_2	*Dibunophyllum* in stage ψ. *Productus latissimus*.	...	...	Kent's Channel Beds.	...	Great limestone, Teesdale and Weardale.	Limestone of Hull Pot Gill.
	Productus giganteus. *Lonsdaleia floriformis*.	Outscar Beds. Bampton, etc.	(?)	Humphrey Head, east side. *Petalaxis Portlocki*. *Cyathophyll. regium*.	(?)	*P. giganteus* beds. 'Scar limestone.' *Lonsdaleia* bed. Hilton Beck, Hardraw Scar, etc., etc.	Hunt Pot Beds, with *Dibunophyllum* aff. ψ. *Spiriferina* cf. *octoplicata*.
D_1	*Dibunophyllum* in stage θ. *Cyathophyllum Murchisoni*.	Upper Knipe Scar. Up. Hardendale Nab. Upper Orton Scar.	(?)	Humphrey Head, west side. Eggerslack Beds.	Serpentine Walks Limestone.	Upper Melmerby Limestone of Middle Tongue Crag, etc.	Upper Ingleton (White Scars) Beds. *Dibunophyllum* aff. θ.
	Productus corrugato-hemisphericus. *Chonetes papilionaceus*.	Lower Hardendale Beds.	? Waitby Beds.	Arnside Knott and Wharton Crag.	Upper Scout Scar Beds.	Lower Melmerby Limestone. Long Fell, Musgrave Scar, etc.	*Chonetes papilionaceus* beds, White Scars, Moughton & Horton Sc.
S_2	*Nematophyllum minus*. *Cyrtina carbonaria*.	? Ashfell Sandstone.	Smardale Fell. *Cyrtina* beds. Upper Ashfell Sandstone.	Hampfield Beds. Lower Wharton Scar. Far Arnside, Middlebarrow, and Sandside Quarries.	Lower Scout Scar Beds. Kendal Fell. Kettlewell Quar. *Cyrtina* bed.	? Bituminous limestone beds of Roman Fell.	*Bellerophon* beds of Horton, Coombe and Craven Quarries, with *Nematophyllum minus*.
S_1 C_2	*Michelinia megastoma*. *Caninia cylindrica*. *Chonetes* cf. *comoides*.	? Water's Farm Series. *Camarophoria isorhyncha* bed. ? Dorker Beck Oolites. ? Gastropod bed.	? Lower Ashfell Beds. ? Upper Ravenstonedale Limestone.	Blackstone Pt. Beds. Arnside Beds, with *Z. cornucopiæ* and *Chonetes* cf. *comoides*.	Barrowfield Beds Kettlewell Cave Beds.	Roman Fell Sandstones, with *Syringothyris* cf. *cuspidata*.	? *Paludina* shale, Horton in Ribblesdale basement bed, Ingletondale, etc., with *Michelinia* and *Caninia*.
? C_1	*Syringopora* cf. *reticulata*. *Diphyphyllum pseudo-vermiculare*. *Productus* cf. *burlingtonensis*.	*Diphyphyllum* bed. Raisbeck, etc. *Spiriferina* shale. Bryozoa bed.	Middle Ravenstonedale Limestone.	Meathop Fell Beds.	*Cyathophyllum* cf. *Murchisoni* bed. Crag Mollet *Diphyph'm* bed.		
? Z	*Athyris glabristria*. *Spirifer clathratus*.	Basement conglomerate.	Stone Gill Beds. Basement beds Pinskey Gill, etc.				

A (?) placed before a bed implies that the index fossil has not been found in it.

In the Horton district we appear to have a normal succession. On Ingleborough, above the *Caninia* basement bed S_2 is represented by the *Bellerophon* bed with *Nematophyllum minus*, and is in all respects similar to the same zone on Scout Scar, Hampsfield Fell, etc. Above these, beds rich in *Chonetes papilionaceus*, *Lithostrotion Portlocki*, and *Alveolites septosa* succeed, and corals allied to *Dibunophyllum* ϕ are not uncommon still higher with characteristic *Producti*. But I do not know of the occurrence of *Lonsdaleia floriformis* or *Productus giganteus* on Ingleborough. On Penygent, however, at Hunt Pot, we have a rich fauna of upper *Dibunophyllum* age containing, beside the typical *Productus giganteus*, *Lonsdaleia floriformis*, *Dibunophyllum* aff. ψ, *Lithostrotion junceum*, etc. In the lower shale band a *Spiriferina* closely related to *octoplicata* is common, and Dr. Vaughan tells me that he has lately traced Sowerby's type-specimen of *Spiriferina octoplicata* to an horizon which appears to be D_2, the identical horizon of the Hunt Pot Beds.

The bed above this on Penygent is frequently crowded with *Productus latissimus* and thick reefs of *Dibunophyllum* in the ψ stage, a form which appears to be larger and longer than the typical examples. This bed is represented on Ingleborough by the cement-stone bed seen in the swallowhole dedicated in the Ordnance map to Tatham's wife, and is also found at Ribblehead. The same zone occurs in the Wensley Dale district at the top of the Hardraw Scar Limestone, while the bottom of that bed is full of typical *Productus giganteus*.

The highest zone in the district, that contained in the Upper Scar Limestone, shows a further modification of the giant *Producti* to a form which, some years ago, I tentatively referred to the variety *Edelburgense*.[1]

IV.—The Rocks of Northern Guernsey.

By John Parkinson.

Introduction.

In a communication to the Geological Society in 1900 I had occasion to compare the rocks of the south-eastern coast of Jersey with the hornblende gabbro, diorites, and granites of Northern Guernsey; and to point out that in general terms the petrographical types of the two islands bore a close resemblance to each other, group for group, in sequence and general relations. Since work abroad renders it improbable that I shall be able to devote much additional time to this subject, the following notes are given as a possible aid to future observers.

The very valuable work of the Rev. Edwin Hill[2] in this island renders superfluous any lengthy note on general characters; suffice it to say that the southern part of the island consists of gneiss with a few intrusive masses and dykes; the northern of diorites and intrusive granites, except for an oblong area on the eastern coast,

[1] I here limit the term *giganteus* to the large coarsely-ribbed forms found, as far as I am aware, only in the *Dibunophyllum* zone, and usually confined to the upper part of that zone.

[2] Quart. Journ. Geol. Soc., vol. xl (1884), p. 404 and map.

between St. Peter's Port and St. Sampson's, which is composed of hornblende gabbro.

In the present paper the field evidence will be briefly reviewed, and reference made to the microscopic work only when necessary.

The subject can be divided into two parts—

(1) The hornblende gabbro,

(2) Sections on the northern and western coasts.

(1) The Hornblende Gabbro.

Detailed examination of the coast between St. Sampson's and St. Peter's Port resulted in the following conclusions:—

(*a*) A hornblende-labradorite rock, the former mineral more or less completely replacing augite, is characteristic. The rounded outlines of the ferromagnesian mineral give a spotted appearance to this rock, which may be considered as typical of the locality ('bird's-eye' of quarrymen). It varies remarkably, however, in the relative quantity of the distinctive minerals present, i.e., either felspar or ferromagnesian constituents may predominate; such alteration taking place, sometimes as a gradual change, sometimes as a more rapid alternation of parts, of the nature of banding, in which the constituents are equally distributed.[1] A common variation results in a fine-textured rock, more basic than the average, in which the hornblende is original and not secondary, elongated prisms predominating instead of a rounded poecilitic form of augite; and the mineral, as seen in a thin section, is almost opaque through the presence of opacite. A banded structure, the occurrence of less clear and well-defined streaks differing mineralogically from the surrounding rock, and the parallel arrangement of such a mineral as hornblende indicate fluxional movement, and give rise to the irregular approximation of varieties differing considerably in composition.

(*b*) Later dykes cut these rocks, and belong to at least two periods. The earlier are rich in hornblende; the later, often very abundant, consist almost entirely of felspar.

A thin section of the former shows that hornblende composes at least half the rock. It forms polygonal grains (average size ·009 inch, but frequently considerably larger, say ·03 inch), which approach to an ophitic structure through the earlier consolidation of the felspars, but have a tendency to gather into groups of grains to the entire exclusion of this mineral.

The more acid dykes show a strong tendency to follow the directions taken by the earlier system, with the result that a kind of composite dyke is produced. The variations in the hornblende gabbro go to show that a rock which forms a dyke in one place may in another pass gradually into one on the whole older which surrounds it. This close relationship is strongly borne in upon the observer. Especially noteworthy are the large elongated hornblendes in the felspar dykes, producing a close resemblance to the extreme felspathic variation of the 'bird's-eye.' The dimensions of the dykes exercise no influence on the dimensions of the hornblende.

[1] See Professor Bonney's description: Quart. Journ. Geol. Soc., vol. xl (1884), p. 425. Mica is rare in these rocks.

A thin section cut from one of these shows that the characteristic mineral is obscured by secondary products, but such extinctions as can be seen indicate labradorite. The crystals are occasionally zoned. A few grains of apatite and ilmenite are the only accessory minerals.

The felspathic dykes contain also darker shreds and inclusions, sometimes clearly, sometimes indefinitely outlined, suggesting that a local absorption of derived fragments attended the intrusion. Occasionally a more definite arrangement of parts produces a rude banding. Thus in one instance the centre of such a dyke, cutting the ordinary 'bird's-eye,' was dark-coloured and close-grained, about 1½ inches across, and bordered by a narrow felspathic edge, not sharply marked off from the surrounding rock, while one or two identical felspathic patches were contained in the central part and were disposed roughly parallel with the direction of the dyke.

The dioritic rock, referred to under the heading Hornblende Gabbro (*a*), is found also as ill-defined fragments lying in a more felspathic matrix, which nevertheless contains a considerable quantity of hornblende. Other inclusions occur, petrologically inseparable from the hornblende dykes, while the rocks rich in felspar in which they lie are indistinguishable from the later dykes when these contain hornblende.

A note by the Rev. Edwin Hill and Professor T. G. Bonney on a banded specimen of 'long-grain' and felspathic rock from here, is of interest in this connection.[1] The inferences drawn as to the possible derivation of the hornblende from augite and the occurrence of biotite as a derivative from the former mineral are entirely in accord with my own work, as is also the conclusion that the rock "exhibits an imperfect mixture of two magmas" (p. 137). A slight difference in the physical state of either or both of the magmas may give rise on the one hand to a brecciation, on the other to interbanding.

Examination of Bordeaux Harbour and the shore between Hougue à la Perre and St. Peter's Port did not appear to me to warrant the conclusion that the hornblende gabbro was genetically distinct from the dioritic rocks to the north and south.

(2) Sections on the Northern and Western Coasts.

(a) East Shore of Grande Havre.—The quarry at the south-east angle of Grande Havre is excavated in a fine-grained mica diorite containing a little quartz. A thin section shows that the hornblende is intimately associated with biotite, which apparently replaces it, and forms a kind of matrix to the other minerals. A coarser rock consisting of plagioclase, some orthoclase, and a considerable quantity of quartz (sometimes a full third of the rock) is intrusive into it. The junction, which is not very clearly defined, is made apparent by the greater size of the felspars of the more acid rock, accompanied by the development of biotite to the exclusion of hornblende. The quartz has corroded the felspar. The more basic side of the junction consists of plagioclases varying from oligoclase to labradorite, usually

[1] Quart. Journ. Geol. Soc., vol. xlviii (1892), p. 135.

with a more translucent border, a little quartz, a considerable quantity of brown mica in flakes up to ·028 inch across, and green hornblende taking the form of rounded polygonal grains. Further observation shows that the younger of the two varies greatly in composition, and, although usually containing hornblende and conspicuous crystals of biotite, yet the dark minerals may be locally absent or represented by a group of irregularly disposed and elongated hornblendes, always considerably larger than any of the other constituents. Naturally there are many minor variations. For example, a slab may consist of two slightly different rocks, distinguished principally by their relative amounts of hornblende; the less basic containing drawn-out patches of a finer textured and darker rock. Fluxional movement is indicated by bands of different mineral composition, which occasionally are traceable for eight or ten feet. The almost invariable presence of quartz and the common occurrence of large ragged plates of biotite distinguish these rocks at once from the hornblende gabbro of the east coast.

(*b*) *The East Coast North of the Hornblende Gabbro.*—At Hommet Bennest, to the north of Bordeaux Harbour, we find a close-grained diorite weathering grey through the presence of felspar, which predominates slightly over the hornblende. This rock is veined and streaked by one still more felspathic, which contains a ferromagnesian mineral. The older of the two rocks consists of a felspar too opaque for determination, slightly earlier in consolidation than the hornblende, an altered mica, and a little magnetite. Small patches of quartz and a translucent felspar are found here and there. Hornblende bordering these patches assumes the form of an actinolitic fringe. Comparison with other slides suggests these patches are the early stages of a permeation by a more acid magma.

(*c*) *From Vale Castle to Fort Norman.*—A uniform blue-coloured quartz-diorite with no clear signs of veining or intrusion is quarried along the shore to the north of Vale Castle. This is a variety of the older rock of Grande Havre Quarry—a quartz-mica diorite. We meet with a very similar rock to the west of Lancresse Common, but differing in being richer in quartz and biotite. In both slides the felspars are often zoned, the outer border more translucent than the centre, while the higher extinction angle and irregular outline of the central part suggests the corrosion of a basic species. A little more than half-way between the Castle and the Fort the diorite is cut by a lighter-coloured and coarser rock, containing, however, some quantity of hornblende, which locally assumes an elongated outline.

The character of the intrusion is irregular and streaky. On a jutting headland to the south of the Fort is a fine-grained diorite like that of Hommet Bennest, consisting of hornblende and felspar, the latter slightly the earlier in crystallization, some is untwinned, but plagioclases occur varying from oligoclase to labradorite. It is broken by veins or dykes of a felspathic rock speckled with hornblende. Occasionally dykes, about an inch wide, can be traced for five or six feet. A thin section across the junction exhibits the following association: a fine-grained quartz-free hornblende plagioclase rock on the one side, a coarser quartz hornblende felspar rock on the other.

The latter is the intruder, but the boundary between the two is quite indefinite, partly no doubt owing to the opaque state of the felspars, which hinders a precise determination. In the older rocks the hornblende formed after the plagioclase, and is locally replaced by biotite; in the younger the quartz is inconspicuous, and plagioclase is plentiful (oligoclase to labradorite), with a tendency towards idiomorphism.

A striking contrast exists between this rock and the intrusive member at Grande Havre. Not only is the latter coarser, but its plentiful quartz and biotite distinguish it at once from any rock on the east coast, while the former is not unlike the late felspathic dykes cutting the hornblende gabbro.

(*d*) *East and South of Fort Marchant.*—At the southern end of the Fort Marchant peninsula the diorite contains rounded hornblendes, resembling the spots on a trout, with which is associated a variety containing the same mineral as elongated prisms. Both are veined by a third rock, richer in felspar (some orthoclase and acid plagioclases), and containing a little quartz, some biotite, and green hornblende.

This assemblage, for the members cannot well be separated, passes into a rock which, although poorly developed, is identical with the 'bird's-eye' of the shore to the north of St. Peter's Port. It contains segregations of hornblende and locally more felspathic patches containing hornblendes, connected in some instances with irregular veins.

Similar phenomena of variation, and intrusion which may be called intermingling, are abundant elsewhere in the northern part of the island. Thus we find evidences of a brecciation more or less sharply defined all over the quarries near the Saumerez Monument.

The younger rock is of a more granitic composition than that into which it has forced its way, and when pure, i.e. unassociated with fragments, seemingly not rich in either black mica or hornblende. The older rock is a quartz-diorite, on the whole uniform in texture, but which contains more basic fragments, having edges sometimes well defined, sometimes passing into the surrounding rock in a cloudy way, a zone half-an-inch or so wide being common to both.

Locally the invading rock is distinctly streaky; the whole suggesting that the older member was in a state of imperfect consolidation at the time of the intrusion of the more acid magma, and that some absorption took place.

The hornblende-felspar rocks south of Fort Norman and from Hommet Bennest are essentially the same as the more basic parts of rocks from the west of Fort Doyle and the black dykes cutting the 'bird's-eye' of the St. Sampson's area.

Conclusions.

1. That in the northern half of Guernsey we have a series of igneous rocks, which, with the probable exception of some granites on the west coast, are related to each other as the products of differentiation of a single magma.

2. Some evidence exists for a progressive increase in acidity in going north and west.

V.—On a new Brachyurous Crustacean from the "*Clypeus*-Grit" (Inferior Oolite) of the Cotteswold Hills.

By Henry Woodward, LL.D., F.R.S., F.G.S.,
late Keeper of Geology, British Museum (Natural History).

IN November last Mr. L. Richardson, of Cheltenham, very kindly sent me (with other fossils for inspection and determination) the carapace of a small Crustacean from the "*Clypeus*-Grit" of the Cotteswolds, which had been picked up and given him by Mr. C. L. Walton. As Mr. Richardson anticipated, the species proves to be new to this country, and I readily obtained his permission to describe the same.

Forty years ago (in November, 1866) I communicated to the Geological Society of London an account of the then oldest known British crab, *Palæinachus longipes*, from the Forest Marble of Malmesbury, Wilts (see Quart. Journ. Geol. Soc., vol. xxii (1866), pp. 493–494, pl. xxiv, fig. 1), obtained by the late Wm. Buy, of Christian Malford, the well-known collector of Oxford Clay and Oolitic fossils. This form (which has the limbs preserved and still attached to the carapace) agrees closely with the living 'Spider-crabs' of the genus *Inachus*, and differs generically from the newly-discovered fossil. Two years later, in 1868, I described an Oolitic crab from the "Stonesfield Slate," of which three specimens (two of them very imperfect and one a nearly perfect carapace) are known. It was named by me *Prosopon mammillatum* (see Geol. Mag., 1868, p. 1, Pl. I, Figs. 2, 2*a*). This crab carried the Brachyurous Decapods considerably further back chronologically, than the Forest Marble example, which in its turn has now been surpassed in age by the newly-discovered specimen from the "*Clypeus*-Grit" of the Inferior Oolite. The Stonesfield crab, *Prosopon mammillatum*, although near generically to the new crab, is twice its size, and differs in several important details from it—especially in the frontal region of the carapace—but the absence of limbs and other ventral and oral structures renders strict determination rather unsatisfactory.

Fortunately Professors Reuss[1] and Herman von Meyer[2] have described and figured three genera and twenty-nine species of small crab carapaces, some fifteen of which have been retigured by me in Salter & Woodward's Chart of Fossil Crustacea.[3] These are from the Upper White Jura of Oerlinger Thal and other localities in Germany, also one from the Lower Oolite, three from the Coral Rag, and one from the Neocomian. In my paper in 1868 (Geol. Mag., January, pp. 3–4), I endeavoured to separate von Meyer's Oolitic species of the genus *Prosopon*, and referred eleven of them with some hesitation to Bell's genus *Plagiophthalmus* (op. cit., p. 4). Of the remaining species—still retained by me in the genus *Prosopon*—those *most nearly* related to the new species from the "*Clypeus*-Grit" are *P. marginatum*, *P. grande*, *P. excisum*, and *P. lingulatum*. To these also most probably belong *P. elongatum* and *P. sublæve*.

[1] Sitzungsb. k.k. Akad. d. Wiss. in Wien, xxxi. 1858.
[2] Mon. Prosoponidæ: Palæontographica, 1859–61, Bd. vii, p. 183, t. xxiii (Cassel).
[3] Catalogue and Chart Fossil Crustacea, 1865, figs. 1–15.

Subclass **MALACOSTRACA.**

Order 1. PODOPHTHALMA.

Suborder 1. BRACHYURA.

PROSOPON RICHARDSONI, H. Woodward, sp. nov. (Fig. 1.)

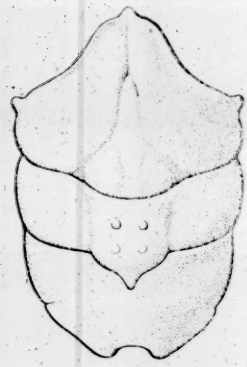

FIG. 1.—*Prosopon Richardsoni*, H. Woodw., sp. nov. Enlarged 2½ times nat. size. *Clypeus*-Grit, Inferior Oolite: South Cotteswolds. From the collection of Mr. Linsdall Richardson, F.G.S., of Cheltenham.

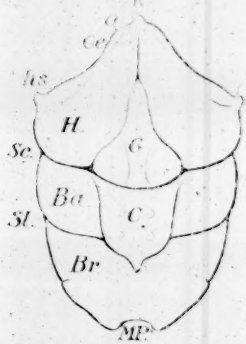

FIG. 2.—Outline key-figure to regions of carapace of *Prosopon Richardsoni*, H. W. *R.* rostrum; *O.* orbit; *hs.* hepatic spine; *Sc.* cervical furrow; *Sl.* lateral furrow; *MP.* posterior margin; *Ge.* epigastric lobe; *H.* hepatic region; *G.* gastric lobe; *C.* cardiac region; *Br.* branchial region; *Ba.* epibranchial lobe.

Diagnosis.—Carapace 21 mm. long by 15 mm. broad; frontal border broadly triangular, converging from the small hepatic spines (*hs.*) on the margin of the hepatic region (*H.*), where the width is 14 mm., to the obtusely prominent rostrum (*R.*), the frontal lateral margins being at first slightly concave, but becoming roundly convex as they join the rostrum, which is curved downwards at its point and furrowed along its centre. The orbits (*O.*) are not clearly to be made out. The gastric lobe (*G.*) lies in front of the cervical furrow (*Sc.*), and is 9 mm. broad at its base, its sides uniting to form with the base a triangle, 6 mm. long, terminating in a narrow acuminate point on the centre line of the carapace, where it merges in the rostral furrow. Immediately behind the gastric lobe is the cardiac region (*C.*), forming a shield-shaped escutcheon, 5 mm. broad in front, and terminating behind in a point 6 mm. from the cervical furrow on the central line and 5 mm. from the posterior margin (*MP.*); the lateral furrow (*Sl.*) crosses the carapace 4 mm. behind the cervical furrow (*Sc.*) and nearly parallel with it, but is interrupted by the shield-shaped cardiac escutcheon in the centre of the carapace, which is here 13 mm. broad; this furrow divides the branchial region into the epibranchial (*Ba.*) in front of (*Sl.*) and the branchial (*Br.*), which lies behind it. The carapace is rounded on its posterior-lateral border, and contracts to its posterior margin (*MP.*), which is 7 mm. in breadth and slightly

emarginate. There is no evidence of any abdominal or caudal segments having been preserved, the ventral surface being firmly imbedded in very hard matrix.

There is evidence of the presence of four minute rounded tubercles on the surface of the cardiac region (*C.*), but as the carapace is decorticated it may have had other small papillæ upon its perfect test. No appendages of any kind are preserved.

Formation.—"*Clypeus*-Grit," Inferior Oolite.

Locality.—Tor Hill, near Wotton-under-Edge, South Cotteswolds.

Collection.—Mr. Linsdall Richardson, Cheltenham.

Remarks.—Although, thanks principally to the memoir of Herman von Meyer (1859), we are acquainted with quite a number of small carapaces of Crustacea of an oblong-oval form, from strata somewhat similar in character and age to that now under consideration, it is difficult without a knowledge of their appendages or the ventral surface of the carapace to place such forms more than approximately in their natural family, in relation to existing forms. There is, too, a strong tendency amongst these earlier Secondary Crustacea to present, in the same individuals, characters observed to be peculiar to distinct families in more modern times.

Thus it becomes difficult in the species of the genus *Prosopon*, which are only known by their carapaces, to refer them to the Maioidea (=Oxyrhyncha), the Leucosiidea (=Oxystomata), or to the Anomura (=Anomala), to each of which groups they seem to show synthetic relations.

In the evolution of the short-tailed crabs (Brachyura) one feature of great interest is the very noticeable change in the form of the carapace or cephalothorax. Thus in most modern crabs the body is broader than it is long, but in the earliest forms it is longer than broad. If the elongation of the cephalothorax is further accompanied by the exposure of the abdomen, which in most of the section Brachyura is quite small and carefully concealed beneath the cephalothorax, then the division between the short-tailed crabs (Brachyura) and the long-tailed lobsters and prawns (Macroura) disappears, and they become one group (the Decapoda).

No crabs are met with after the close of the Secondary period, but the Macroura are found in the Carboniferous rocks. These show evident signs of a further modification in structure, and we find many characters of the Schizopoda (the Squillidæ and Mysidæ) incorporated into the Macrouran Decapods of the Coal period. Thus the Podophthalma (stalk-eyed Crustacea), which exist now and in Oolitic times as *three* distinct suborders, were apparently represented in earlier post-Carboniferous times by two and in Carboniferous times by only *one* order. In point of fact, it is amongst these earlier individual forms of Arthropods that we should naturally expect to find those more generalized characters which occur in several distinct types only at a much later period in geological time.

I dedicate this little crab to Mr. Linsdall Richardson, who has devoted so much time to the unravelling of the stratigraphy of the Inferior Oolite of the South Cotteswolds of the Bath–Doulting district.

VI.—On the Stratigraphical Position of the Beds from which *Prosopon Richardsoni*, H. Woodward, was obtained.

By L. Richardson.

As some months will elapse before the results of my investigations of the Inferior Oolite and contiguous deposits of the district between Doulting, near Shepton Mallet, and Stroud, are published, in order to show from which beds the *Prosopon* described by Dr. Henry Woodward, F.R.S., was probably obtained, it appears desirable to give an outline of certain of these results.

In the Doulting–Bath district the greatest number of subdivisions of the Inferior Oolite that can be recognised are six. They are, in ascending order, the Upper *Trigonia* Grit, Dundry Freestone, Upper Coral-Bed (or "Coralline Beds"), Doulting Stone, *Anabacia* Limestones, and certain rubbly beds, which, for want of a better term, may be called the "Rubbly Beds." In the whole of this Doulting–Bath district there is no Inferior-Oolite deposit of pre-*garantianæ* date. The deposit of *garantianæ* hemera, the Upper *Trigonia*-Grit, when traced from the neighbourhood of Bath towards the Mendip Hills is seen to transgress the outcrop edges of successively older beds. In a shaft on Timsbury Sleight, Timsbury, near Radstock, and also in the roadside section at Midford, it is seen to rest, non-sequentially of course, upon the Midford Sands. In the section by the railway bridge at Wellow it rests upon the Cephalopod-Bed of these parts, which, instead of coming *above* the "Sands," as does the Cephalopod-Bed of the Cotteswold Hills around Wotton-under-Edge, comes *below*. In the railway-cutting at Mells-Road Station the meagre representative of the Upper *Trigonia*-Grit reposes directly upon Liassic clays; but in the Vallis, near Frome, the "grit" has been overstepped by the Doulting Stone, which may be seen near Hapsford Mills, Elm, resting on a very much bored, planed, and oyster-covered surface of the Rhætic White Lias, and in the same neighbourhood upon an equally bored, planed, and oyster-covered surface of the Carboniferous Limestone.

Above the Upper *Trigonia*-Grit in the neighbourhood of Timsbury Sleight is a representative of the Dundry Freestone, and above that deposit the Upper Coral-Bed. The geographical extent of the freestone in this area is very restricted. It is represented in a section at English Combe, near Bath, but it is absent from the section at Midford, where the Upper Coral-Bed rests non-sequentially upon the Upper *Trigonia*-Grit. The Upper Coral-Bed, on the other hand, has a very considerable geographical extent. It is intermittent, it is true, but by means of its corals, brachiopods, and micro-organisms, it can be demonstrated that the well-known coral-beds of Midford, Rodborough Hill, and Worgen's Quarry, near Stroud, and the "Coralline Beds" of Dundry, are widely-separated patches of a contemporaneous deposit.

The remaining intervening deposits between the Upper *Trigonia*-Grit and the Fullers' Earth, namely, the Doulting Stone, *Anabacia*-Limestones, and Rubbly Beds, may collectively be called the "Doulting Beds." As far as I can see at present the beds known as the "*Clypeus*-Grit" in the Cheltenham District are equivalent to these Doulting

Beds. As far north even as Nailsworth, near Stroud, it is quite easy to identify the equivalents of the Doulting Stone and *Anabacia*-Limestones; but the Doulting Stone has become much more rubbly and fossiliferous. At Scar Hill, Nailsworth, the top-portion of the beds, which I correlate with the *Anabacia*-Limestones, are incipiently rubbly; and, indeed, as these Doulting Beds are traced farther north they become as a whole more rubbly, until in the *Clypeus*-Grit of Cleeve Hill, to the north-east of Cheltenham, it is not easy to identify the equivalents of the Doulting Stone, *Anabacia* Limestones, and Rubbly Beds, although it can be done with a tolerable degree of certainty.

The quarry at Tor Hill may be divided, for descriptive purposes, into two portions—a lower, in which the massive oolitic limestones (which in this neighbourhood occur immediately below the Upper *Trigonia*-Grit) are worked; and an upper, in which the Upper *Trigonia*-Grit and rubble of higher beds was formerly quarried.

The carapace of the *Prosopon* given to me by Mr. C. L. Walton was picked up; it was not found *in situ*; but from the matrix I have no doubt whatever that it came from the Doulting Beds, and probably from that division of them which corresponds to the *Anabacia*-Limestones of the Doulting–Bath district. Unfortunately, however, only rubble of these beds caps the Tor-Hill section, but at Winner Hill—the next promontory to the south—there is a quarry in which a very satisfactory view of these top-beds is obtainable. The section is as follows:—

Quarry at Winner Hill, near Wotton-under-Edge.

		Thickness in ft.	in.
Rubbly Beds?	1. Limestone, coarsely oolitic, the edges of the flaggy pieces weathering into an oolitic 'marl'; *Terebratula globata*, Sow., *Rhynchonella* cf. *hampeneusis*, S. Buckman; not uncommon in a bed at 2 feet above the base. The bottom-bed is more regular and has an even under-surface: seen 3 or 4 feet	3	6
Anabacia-Limestone equivalent.	2. Limestone, harder than the beds below, fine-grained matrix with large yellowish oolite-granules; maximum	1	1
	3. Limestones, yellowish, somewhat coarsely-oolitic in places	5	0
Doulting-Stone equivalent.	4. Limestone, greyish, fairly distinct bed on the south side of the quarry; no fossils recorded	0	11
	5. Limestone; *Ter. globata*, *Rhynchonella*, sp. indet., *Pecten* (*Syncyclonema*) aff. *demissus*, Phillips, *Serpula* sp. (same form as at Doulting)	0	5
	6. Limestone, massive, rubbly at the base, where *Ter. globata*, *Rhyn.* cf. *hampeneusis* are not uncommon; *Acanthothyris spinosa* (Schloth.) ...	1	9
	7. Parting of brown shaly matter	0	0½
	8. Limestone, very hard, but rubbly at the centre; *Pecten* (*Syncyclonema*) aff. *demissus*, Phillips, *Ter. globata* (rare), *Acanthothyris spinosa*	3	0
	9. Brownish marly deposit, no micro-organisms seen (C. Upton); 0 to 2 inches	0	1

		ft.	in.
	10. Limestone, grey, oolitic, with a very uneven top: 4 to 8 inches	0	6
	11. Limestone, rubbly, slightly ironshot: 2 to 5 inches .	0	3½
Upper *Trigonia*-Grit.	12. Ragstone, hard, grey, shelly; *Trigonia costata* (common in the upper portion), *Acanthothyris spinosa*, *Ter. globata*, *Pteria digitata*, *Nerinæa* sp. The top-surface is covered with oysters, and bored in places by *Lithophagi*: seen	2	0

It was from rubble of the *Anabacia*-Limestone equivalent, I think, that the *Prosopon* was obtained at Tor Hill.

Concerning the Winner-Hill section, it may be remarked that there is no clear representative of the Dundry Freestone or of the Upper Coral-Bed. The oyster-covered and bored top-portion of the Upper-*Trigonia* Grit hints at a non-sequence.

VII.—Note on the Occurrence of Arenig Rocks in the West of Ireland.

By H. B. Muff, B.A., F.G.S., and R. G. Carruthers.

WHILST examining the tract of Lower Palæozoic rocks and metamorphic schists around Killary Harbour, in Connemara (an examination primarily undertaken to ascertain the relations of the fossiliferous sediments to the schists in that area), an extensive tract of Arenig rocks has been discovered on both sides of the harbour. In 1905 *Didymograpti* of the *extensus* and *superstes* types were found, and during last Summer several specimens of *Phyllograptus* and *Tetragraptus* also, together with many other forms.

Professor Lapworth and Miss Wood (Mrs. Shakespear), who kindly examined some of the best preserved specimens, are of opinion that certain of the graptolites resemble American forms, and may include genera and species new to Britain, though they do not wish to give a definite opinion until more specimens have been obtained. From the evidence already before us it would appear that either a great reversed fault or upturned thrust plane must separate the Arenig rocks on the north from Ludlow beds on the south. The members of both groups dip to the north, the Ludlow rocks passing beneath the Arenig strata. It may be added that an abundance of rock-sections and an apparent absence of acute folding give every hope that the structural relations of the rocks and the distribution of this peculiar fauna may be fully elucidated in the near future.

On the maps of the Geological Survey published in 1874 the lowest fossiliferous Silurian rocks (Doolough Beds) are lettered b^2, and are referred somewhat doubtfully to the Lower Llandeilo in the Memoir on Sheets 83 and 84. During the revision of the district in 1896 black shales with Lower Llandeilo fossils were proved in several localities, and it was suggested that "perhaps even Arenig graptolites" might be present.[1]

[1] Annual Report of Geol. Surv. for 1896, p. 49.

VIII.—Note on the Ballycastle Coalfield, Co. Antrim.

By Grenville A. J. Cole, F.G.S.

THE recent development of mining in the central area of the Ballycastle Coalfield in Co. Antrim has given rise to several articles in the daily Press, and it seems worth while to point out that the occurrence of coal-seams in the interior of the field was long ago proved by borings (see Geological Survey Memoir to Sheets 7 and 8, Ireland, published in 1888); while Mr. Symes's longitudinal section, Sheet 30, published by the Geological Survey of the United Kingdom in 1890, indicated faithfully the geological conditions. The possibility of further development is also mentioned in "Ireland, Industrial and Agricultural," published by the Department of Agriculture for Ireland in 1901.

It was left, however, for the North Antrim Mining Syndicate, in the last two years, to make a systematic trial of the coalfield, and to prove the exact position of the seams of coal. The shaft that has now been sunk, under Mr. Braude's direction, is the result of well-planned preliminary borings. It is hardly necessary to add that, despite the assertions of the Press, the Director of the Geological Survey of Ireland did not furnish any report on the capacity of the field to the Mining Syndicate, though he was freely shown what was going on. Mr. Braude was, moreover, able to point out an extension of the Calciferous Sandstone at one point to the south of the line drawn on the geological map of 1887, and Mr. McHenry has since revised this boundary for the Survey. But no conflict of opinion has been raised between former and present members of the Survey Staff, the geological relations of the strata, coal-seams, and ironstone being already correctly appreciated. Professor Hull's statement in the Report of the Royal Commission on Coal Supplies in 1905, to the effect that the resources of the Ballycastle area "may be considered as practically exhausted," was, it may be added, regarded in Ireland with some astonishment, in view of the records published under his care some eighteen years ago. It is probable from the context, however, that Professor Hull was thinking of the region bordering on the coast, and did not consider the inland area in preparing his report.

REVIEWS.

I.—The Tremadocian Series of Sweden. Note upon the "Bidrag till Kännedomen om Ceratopygeregionen," with special reference to its Development in the District of Fågelsång in Skåne. By J. C. Moberg and C. O. Segerberg, Meddelande från Lunds Geologiska Fältklub. Ser. B, No. 2. Lund, 1906.

THE memoir before us forms the second of an important series of monographs devoted to the study of the detailed palæontology and subdivision of well-recognized stratigraphical series as developed in South Sweden and Scandinavia generally. The present volume deals with the series which Dr. Marr would term Tremadocian, and affords a powerful plea for the retention of that series as the basal member of the Ordovician system.

As stated in the preface, it would seem that the work for the memoir was begun by the author whose name appears second, and submitted as a degree thesis to the Lund University as long ago as 1895. Much of the material then collected was, however, quite new, and as its determination demanded more time than its collector could afford, it was in 1900 allowed to pass by purchase to the collections of the University Museum. Coming then under the direct notice of Professor Moberg the material has later been further worked up by him, to whom the arrangement of the present paper is doubtless due. The memoir is preceded by an author's bibliography, which, except for the strange omission of such names as Sedgwick, Ramsay, Salter, and other founders of our British Tremadoc Series, seems to be quite complete. The memoir is divided into five sections, which we may consider in order.

Part I is an abstract of the papers mentioned in the bibliography, which are quoted as a history of palæontological discovery among the *Ceratopyge*-bearing beds of Scandinavia and the European continent generally, and discusses at some length the various stages in the evolution of the modern view as to their classification and stratigraphical position. The argument is exceedingly clear, and if a little one-sided is only an advocate's way of stating a strong case. A similar treatment of the history of the shales with *Dictyograptus* and the contemporaneous sandstones and conglomerates with *Obolus* follows, and this with a review of the recent palæontological achievements among Tremadoc rocks of Britain and America concludes the first part of the memoir.

Part II is devoted to a consideration of the possibility of a further subdivision within the *Ceratopyge regio* of various parts of Sweden. In the opening section the *Ceratopyge regio* is defined as being the contemporaneous equivalent of the beds 2*e* and 3*a* of Brögger's Kristiania classification. The *Regio* is therefore directly underlain by the well-recognized zone of *Peltura scarabæoides*, and is overlain by the equally characteristic zone 2 of Törnquist's Lower *Didymograptus* shales (zone of *Didymograptus balticus*). Three very distinct facies of sedimentation are recognized, and the corresponding palæontological table of equivalents is set out as follows:—

	Trilobitic Facies.	Graptolitic Facies.	Brachiopod-bearing Facies.
Upper Division.	Zone of *Apatocephalus serratus*, or Ceratopygekalk.	Zone with *Tetragraptus phyllograptoides* (zone 1 of Törnquist's *Didymograptus* shales).	Not yet studied.
	The *Shumardia* zone, or Ceratopygeskiffer.	Zone of *Clonograptus hœres* (Wgd.), MSS., n.sp.	Not separated from lower zone; contains *Obolus Apollinis*.
Lower Division.	Zone of *Symphesurus incipiens*, not recognized in Sweden.		
		Zone of *Bryograptus Kjerulfi*, along with *Clonograptus tenellus* and var.	
	Zone of *Hysterolenus Törnquisti*, *Boeckia Mobergi*, and *Acerocare* sp.	Zone of *Dictyograptus flabelliformis*.	Zone with *O. Apollinis* (*Obolus* conglomerate and sandstone).

This scheme is in all essentials in complete agreement with the conclusions which I shall express in another place, and is particularly satisfactory to British geologists in that by the inclusion of the *Boeckia* and *Acerocare* zone within the *Ceratopyge regio* the lower limits of that *regio* and of the Tremadoc Slates of Britain become once more identical. The weakest link in the scheme seems to be the presumed contemporaneity of the *Apatocephalus*-bearing Ceratopygekalk, with the graptolite shales with *Tetragraptus phyllograptoides*. The only direct evidence put forward for this contemporaneity is that about Hunneberg in Vestergötland Moberg and von Schmalensee found in 1892 a 2–3 inch band of nodular glauconitic limestone containing *Symphesurus* and *Megalaspis* occurring above the *Tetragraptus phyllograptoides* beds, and they consider that this must be regarded as the *Apatocephalus serratus* zone. In my own examination of the same section last Summer, however, I found that both the basal member of the paler grey shales which underlie the graptolite beds and the highest bank of the dark pyritous 'jernberg' contain *Apatocephalus*; and though I am willing to admit that the greater part of the 'jernberg' contains a fauna more like that of the Ceratopygeskiffer of Norway than that of the Ceratopygekalk of either Öland or Skåne, I am not at all prepared to regard that evidence as convincing proof of the replacement of the *Apatocephalus* zone by *Tetragraptus* shales. The indirect evidence that graptolite beds are generally absent where, as in Öland and Östragötland, the Ceratopygekalk is best developed is certainly striking, but even there *T. phyllograptoides* beds might just as well be represented by Planilimbatenkalk as by the Ceratopygekalk with *Apatocephalus*. In eastern Skåne too the zone of *T. phyllograptoides* is quite well developed, and, as shown by Linnarsson, Holst, and Westergård, is underlain by pale glauconitic and brachiopod-bearing shales and limestone nodules which may well be the *Apatocephalus* beds themselves. In the Kristiania district the *T. phyllograptoides* fauna does not seem to have been recorded, but, unless I am much mistaken, the graptolitic beds which come nearest to the glauconitic Ceratopygekalk at Gjeitungholmen in Kristiania Fjord may with great probability be referred to some part of that zone, and are interbedded with limestone bands very like the upper nodular limestone of Hunneberg discussed above. If, however, Professor Moberg and Dr. Segerberg will admit, as they seem to suggest on p. 44, that the *Ceratopyge regio* shall include some part of the Öland Planilimbatenkalk, the inclusion of the *Tetragraptus phyllograptoides* beds will, I think, be justified, and the upper limit of the Tremadocian as so defined, though somewhat arbitrary in its conception, will at least have the great advantage that it can be recognized and traced over wide areas and through all kinds of sediments. The effect of such a change of nomenclature upon British literature would be hardly noticeable, for except among the Durness Limestone of North Scotland and in the Lake Country the beds affected are represented only by an unconformity. The inclusion of Miss Elles' Lower *Tetragraptus* beds of the Skiddaw Slates with the *Bryograptus* shales of the same series within the Tremadocian would not, I think, be very inconvenient, and the boundary between them has never been mapped, while the recognition

that the Arenig rocks of Arenig include representatives of all the major divisions of the Arenig Series as known elsewhere cannot be regarded as other than a welcome simplification of our nomenclature.

Part III deals with the discovery and detailed description of the Fågelsång section, which now, buried beneath a scree of most unnecessary rubbish, has yielded much valuable palæontological material and intrinsic evidence in favour of the succession already discussed in part II.

Part IV describes the geographical distribution of localities at which the various members of the tabulated succession have been observed.

Part V is the newest and probably the most valuable portion of the whole work; it is a palæontological appendix or monograph of all genera and species which are known to occur within the *Ceratopyge regio* (excluding the *Tetragraptus phyllograptoides* zone) of Scandinavia. The forms discussed are referred to 97 species belonging to 52 genera, and of these 3 genera and 33 species, besides 3 varieties, are described as new. All Swedish forms (and only some 9 of the Norwegian species have not been recognized in Sweden) are represented by one or more beautifully executed figures, some of which are only reproductions of original type figures, but these are in most cases accompanied by one or more carefully drawn new figures of the best obtainable specimen of the species. To each species also is appended a full account of its older figures and synonymy and a list of the more important localities at which it has been recognized.[1] A tabulation and analysis of the occurrence of the individual species among the proposed subdivisions gives the following result:—

(*d*) *Apatocephalus* zone	62 species.
(*c*) *Shumardia* zone	29 species.
(*b*) *Bryograptus* zone	16 species.
(*a*) *Dictyograptus* zone	13 species.

Of these only two species are common to (*a*) and (*b*), 4 to (*b*) and (*c*), 16 to (*c*) and (*d*), and only the single species *Obolus* (*Broggeria*) *Salteri* is known to range through all divisions. In the final zoological analysis attention is drawn to the preponderance of the trilobites (45 species) over Brachiopods (22) and Graptolites (8), but had the *Tetragraptus phyllograptoides* beds and their equivalent been included in the estimate, the result might have been very different, and from my own visit to the *Ceratopyge regio* last Summer I have certainly rather retained the impression that that *regio* is a *regio* of graptolites which includes certain trilobitic and brachiopod-bearing bands.

In conclusion, on behalf of all British students of the Cambro-Ordovician rocks, I will venture to offer my thanks and congratulations to Professor Moberg and Dr. Segerberg on the completion of this useful and monumental monograph of the palæontological aspect of the Scandinavian Tremadocian, and will remark that while its publication does not actually bring about the elucidation of our British Tremadoc rocks it does at least suggest the mode of attack, and in the meantime places in our hands a means of identification of certain of our material such as we might have prayed for. The volume is beautifully printed, and the collotype reproductions of the

seven plates with their two hundred odd figures leaves little to be desired. Why should not some enterprising British Field-clubs emulate this excellent example of a small university field club and give us similar detailed monographs of interesting British deposits? We are indeed behind the times. WILLIAM G. FEARNSIDES.

II.—GEOLOGICAL SURVEY OF CANADA. By ROBERT BELL, LL.D., M.D., F.R.S., etc., Acting Director. Annual Report (New Series), Volume XIV, Reports A, B, F, H, J, M, O, S, 1901. 8vo; with maps. (Ottawa: S. E. Dawson, 1905.)

THE Summary Report (A) of this volume (271 pp.) is for the year 1901; it consists, as usual, of a synopsis of the work done by the field staff, as well as the Museum and office staff. A brief account is given, under the head of "Officers' Reports," of explorations and surveys carried on in all parts of the Dominion, from Yukon in the west to Cape Breton Island in the east. The bare enumeration of all the districts visited by the staff would occupy a considerable space, as there are upwards of thirty. These reports will be reviewed when they are published separately and *in extenso*. One exception may, however, be made. Mr. Lawrence M. Lambe gives descriptive notes on some interesting turtle remains collected during the Summer of 1901 (?) in the Cretaceous rocks of Red Deer River, Alberta. These are referred by Mr. Lambe to *Trionyx foveatus*, Leidy, and *T. vagans*, Cope. The fossils consist of almost complete carapaces of these species, and they supplement in an interesting manner the material obtained in former years.

Report B (R. G. McConnell on the Klondike Gold Fields); Report J (R. W. Ells on the geology of a portion of Eastern Ontario); and Report O (F. D. Adams and Osmond E. Leroy on the artesian and other deep wells on the Island of Montreal), have already been reviewed in the GEOLOGICAL MAGAZINE in 1906.

Report F is a short report by Mr. D. B. Dowling on an exploration of Ekwan River, Sutton Mill Lakes, and part of the west coast of James Bay, with two appendices. The formations observed in the district were: (1) the Cambrian rocks of Sutton Mill Lakes; (2) the Silurian limestone bordering the west shore of James Bay and the south shore of Hudson Bay; and (3) the clays, of Post-Tertiary age, which form the general covering over nearly all the country left by the ancient glacier and the retreating ocean. The appendices consist of a preliminary list of fossils from the Silurian (Upper Silurian) of the Ekwan River and Sutton Mill Lakes, Keewatin, collected by the author in 1901, and afterwards described in full in "Palæozoic Fossils," vol. iii, part 4, 1906, by Dr. J. F. Whiteaves, and a list of 41 species of plants, by Professor John Macoun. The report is illustrated from photographs and original drawings.

Report H is on the origin, geological relations, and composition of the nickel and copper deposits of the Sudbury Mining District, Ontario, by Dr. Alfred Ernest Barlow. Much importance must be attached to this memoir, both from its scientific interest and from the great value of the deposits of nickel so fully described in it. As the report covers

236 pages it will only be possible to bestow a mere glance upon it. The report begins with a history of the development of mining in the Sudbury district, and then goes on to describe its general physical features and geology. The rocks of the district are, in ascending order, as follows:—

1. Lower Huronian. No rocks of this age are at present known in the nickel-bearing area, but this period is represented in part by the banded siliceous magnetites and associated rocks of Hutton and Wissner.

2. Upper Huronian. (*a*) Diorites, hornblende-porphyrites, and green schists; (*b*) conglomerates, greywackes, and quartzites; (*c*) norite and diorite (Worthington mine belt and areas south-east of Evans mine and east of Sudbury).

3. Laurentian. Granite and diorite-gneiss near Wanapitei station.

4. Upper Huronian? Tuffs, felspathic sandstones, and slates classified provisionally on previous geological maps as of Cambrian age.

5. Post-Huronian. (*a*) Granites; (*b*) nickel-bearing eruptive of the main belt (quartz-hypersthene-gabbro or norite, diorite, with their peculiar differentiation product, micropegmatite); (*c*) dykes of olivine-diabase.

6. Pleistocene. Clays and sands.

The granites referred to in the list (5, *a*) are pronounced to be undoubtedly younger in relation to the older diorites, porphyries, and green schists, and a rock which may be called a breccia, formed by an exceedingly intricate intrusion of dykes and masses of granitic material through these basic rocks, covers considerable areas throughout the district.

The nickel-bearing eruptive (5, *b*) is said to be decidedly later than, and intrusive through, the green schists and associated diorites (2, *a*).

The olivine-diabase dykes (5, *c*) cut through, and are therefore later than, all the rocks with which they have been seen to be in contact.

A description is given of the minerals associated with the nickel and copper of the Sudbury region, followed by an account of the methods of mining, metallurgy, and smelting. The nickel deposits of the United States, Scandinavia, and New Caledonia are also described at some length.

The report concludes with a series of statistical tables of the production of nickel in Canada, which is the largest producer in the world; other countries being added for comparison.

This important memoir is well illustrated with plates, maps, and plans.

Mr. Henry S. Poole reports briefly on the Pictou Coalfield of Nova Scotia. This famous coalfield has long been known to geologists through the writings of Gesner, Dawson, Lyell, and Logan. The present report has been written to accompany a revised map of this coalfield and its neighbourhood lately published. The district contains in a small area a wide field for investigation, supplying representative series of several geological epochs and many highly instructive exposures of varied structure.

The geological systems represented are as follows, in ascending order:—

1. Cambro-Silurian.
2. Silurian.
3. Devonian.
4. Carboniferous Conglomerate } Lower
5. Carboniferous Limestone } Carboniferous.
6. Millstone Grit.
7. Coal-measures.
8. Permian.
9. Igneous intrusions in deposits of several ages.
10. Pleistocene.

The detailed Annual Report of the Section on the Mineral Industries of Canada for 1901 by E. D. Ingall and assistants comes next. The report is accompanied by a table of the mineral production of Canada for the calendar years 1886 to 1901.

A very full index and a large number of maps are supplied with this report, which does much credit to the ability and industry of those who have contributed to it. A. H. F.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—December 19th, 1906.—Sir Archibald Geikie, D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "The Post-Cretaceous Stratigraphy of Southern Nigeria." By John Parkinson, B.A., F.G.S.

In this paper, which is a first attempt to outline the sequence of the later deposits of Southern Nigeria (now including the Colony of Lagos), a series of beds are described from four localities—three from the western side of the Niger, and one around Calabar near the Kameruns frontier. The alluvium of the river-beds and the lower terraces are referred to, and the succeeding sediments grouped under three heads.

The youngest of these, termed the Benin Sands, are of wide distribution, and are found extensively developed in all four areas. Their almost universal appearance near the coast, and the height, occasionally 300 feet, to which their denuded tops are now raised above sea-level, indicate an important submergence and subsequent elevation in comparatively late times, while from the latter much of the present physiography appears to date. The Benin Sands have been seen in contact with both the older groups of sediments, but unfortunately the work has not proceeded far enough yet to show conclusively the relationships of the latter.

The older of the two, the Lignite Series, occurs typically near Asaba on the Niger, although indications of a similar deposit have been met with near Moroko, south of Abeokuta; the younger, the Ijebu Series, has so far been found only in that district of the Lagos Province. These beds are extensively impregnated with bitumen. The suggested

difference of age depends on the lesser dip and degree of consolidation of the Ijebu Series. In them a few lamellibranchs have been found, of no value as regards the determination of the horizon, and some plant-remains; in the Lignite Series only undeterminable plant-remains. The Benin Sands are apparently unfossiliferous. The information regarding the Ijebu Beds has been derived almost entirely from boreholes.

2. "The Geology of the Oban Hills (Southern Nigeria)." By John Parkinson, B.A., F.G.S.

The country described in this paper comprises some 1,800 square miles of the Eastern Province of Southern Nigeria, adjacent to the Kameruns frontier. The rocks are crystalline, principally gneisses and schists, with later granites, pegmatites, and basaltic dykes, surrounded on the north, west, and south by Cretaceous sediments. For purposes of description the series is divided under nine headings, according to locality and petrographical character; and it is concluded that, neglecting the basaltic dykes, two broad groups may be distinguished—the one characterized by the presence, the other by the absence, of foliation. In the former the foliation tends to be lost, giving a passage between types which petrographically are acid orthogneisses and granites.

Observation of the banded gneisses, which are typical of several districts, leads to the conclusion that the acid magma is intrusive into mica and hornblende schists, and that the banded gneisses are composite rocks produced by injection. The orthogneisses themselves exhibit many variations; and study in the field shows that the series consists of several members, produced by the differentiation probably of one magma, which have reached their present positions at different times: that is, they differ slightly in age. At Uwet was found a group of phyllites and grits altered into garnet, andalusite, and staurolite-schists, and hornfels, with the development of much biotite, by an intrusive gneiss; and it is considered as probable, though not capable at the time of absolute proof, that the sillimanite-gneisses of the Ekankpa ford, a few miles away, are the result of an extension of the same belt of contact-metamorphism, a suggestion which possibly might truly include the schists of the entire district.

Typical specimens of the granites, pegmatites, and dykes are described, and sketch-maps given.

3. "The Crystalline Rocks of the Kukuruku Hills (Central Province of Southern Nigeria)." By John Parkinson, B.A., F.G.S.

In this paper a short account is given of the crystalline rocks found in the Central Province of Southern Nigeria, between the Station of Ifon (north of Benin City) and the Northern Nigerian frontier. The rocks fall under two heads—(*a*) a group of gneisses and (*b*) a group of schists.

The former is considered as intrusive in the latter, and consists of varieties of biotite gneisses, often well banded, but this group is not infrequently represented by several rocks readily separable by mineralogical peculiarities and by intrusion.

By loss of foliation the gneisses tend to pass into granites, and the series is accompanied by pegmatites.

The second group is distinguished by the wide distribution of quartz-schists, with which occur quartz-mica-schists, mica-schists (locally containing sillimanite), and hæmatite-schists. A partial analysis of a specimen of the last named showed 67·77 per cent. of iron-peroxide.

The district is compared with the Oban Hills of the Eastern Province.

II.—January 9th, 1907.—Sir Archibald Geikie, D.C.L., Sc.D., Sec.R.S., President, in the Chair.

The following communications were read:—

1. "On the Cretaceous Formation of Bahia (Brazil) and on the Vertebrate Fossils contained therein." By Joseph Mawson, F.G.S., and Dr. Arthur Smith Woodward, F.R.S., F.L.S., F.G.S.

This paper relates to a series of estuarine and fresh-water deposits originally described to the Geological Society by the late Samuel Allport, in 1859. The results of thirty years' collecting of fossils are summarized, and the distribution of the formation, so far as determined, is marked on a map. The strata are disturbed by numerous dislocations and discordant dips, and no regular succession of zones or horizons can be discovered. All the more important vertebrate fossils collected are now in the British Museum (Natural History). From these a few remains of new species are selected for special description. A mandibular symphysis of a very large crocodile, with a long garial like snout, belongs to one of the Goniopholidæ. Some Dinosaurian vertebræ seem to belong to the Iguanodont group. A large fish-skull represents a new genus allied to *Macropoma*, and indicates a species five or six times as large as any Cœlacanth previously discovered. The discussion of a complete list of the fossil Vertebrata proves that the formation is of Cretaceous age, and suggests that it may be Lower Cretaceous, as supposed by Hartt.

[Mr. R. B. Newton stated that Mr. Mawson's collections contained some interesting molluscan remains, among which were a number of Anodont—or Unioniform—shells suggestive of *Unio porrectus* and *U. antiquus* of British Wealden areas, associated with *Viviparа*- and *Melania*-like Gasteropods, all of which had been studied by Professor Hartt and later by Dr. C. A. White, both being of opinion that they belonged to the Lower Cretaceous. The vertebrate evidence now brought forward by Dr. A. S. Woodward, especially the newly recorded occurrence of *Goniopholis*, together with the *Lepidotus*-scales originally determined by Egerton, was strong confirmation as to the Lower Cretaceous age of these deposits.]

2. "On a New Dinosaurian Reptile from the Trias of Lossiemouth, Elgin." By Arthur Smith Woodward, LL.D., F.R.S., F.L.S., F.G.S.

Mr. William Taylor, of Elgin, has recently discovered two skeletons of a small new reptile in the Triassic sandstone of

Lossiemouth. Two imperfect skeletons of the same species are also shown on a slab of the same sandstone in the British Museum (Natural History). The head and trunk measure only 4 inches in length, but there is a very long and slender tail. The head is relatively large, and resembles that of *Ornithosuchus* in many respects; but the fossils do not exhibit any teeth. There are about twenty-one presacral vertebræ, of which nine are cervical. There are distinct traces of a plastron of delicate abdominal ribs. The limb-bones exhibit a large internal cavity. The fore-limbs are very small, with a humerus as long as the radius and ulna. The hind-limbs are relatively large, and the ilium is extended antero-posteriorly for the length of four vertebræ. The femur is almost as long as the tibia and fibula; while the metatarsus is especially remarkable, being half as long as the tibia, and consisting of four metatarsals of nearly equal length firmly fused together. The toes are long and slender, with sharply pointed claws. The author concludes that this must have been a running or leaping reptile, and that it represents a new genus of Dinosauria related to the American Triassic *Hallopus*.

Mineralogical Society.

November 13, 1906.—Prof. H. A. Miers, F.R.S., President, in the Chair.

Growth of crystals of soluble salts on each other, by Mr. T. V. Barker. This paper is a continuation of the author's previous work on the growth of salts on isostructural minerals to those of soluble isomorphous salts on each other. The group now investigated is that of the chlorides, bromides, iodides, and cyanides of Na, K, Rb, Cs, and Am, which crystallise in the cubic system. The view previously entertained that parallel growths are conditioned by a similarity of molecular volume is again found to hold good; some apparent exceptions are explained by the presence of isodimorphism. One pair of salts, however, Na Cl–K Cl yield parallel growths, although the molecular volumes are greatly different; this is perhaps to be accounted for by the fact that the molecular volumes are almost exactly in the ratio 1 : 2.—Notes on some Bolivian minerals, by Mr. L. J. Spencer. Descriptions are given of crystallised Jamesonite, Semseyite from Oruro, new crystal-forms on Andorite, Chalcostibite from Oruro, Augelite from Oruro, Vivianite from Tatasi and Tasna, Tetrahedrite from Huanchaca, regular grouping of Stannite and Tetrahedrite, Valentinite, Cassiterite, Tourmaline, and Tourmaline-hornfels, Fluor, Apatite, cupriferous Miargyrite from Tatasi, crystallised Miargyrite from Aullagas, Jarosite from Chocaya, Chalybite from Chorolque and Tatasi, Enargite from Chorolque.—Note on Ilmenite from Brazil, by Mr. G. F. Herbert Smith. The crystals have three habits, *cam*, *camr*X, *cn*X*rs*, differing slightly from those described from the same locality by Hussak. The hemihedrism is shown by striations on the prism faces; some magnesium is present.—Description of the Lengenbach Quarry and of the minerals found there in 1906, by Mr. R. H. Solly. The now well-known quarry was opened about the year 1850, and various new minerals were described by Des Cloizeaux and others. From 1869–70 a level was driven in

a direction at right angles to the stream, and in it were found the specimens described by Von Rath. In the decade 1890–1900 a little work was done each Summer, resulting in the specimens studied by Baumhauer. Since 1900 Francis Jentsch and his partners have worked the quarry regularly each Summer. In 1902 they came across the old tunnel constructed in 1731, the existence of which had been quite forgotten. Up to 1898 eighteen mineral species had been found, of which four are peculiar to the quarry; since that date twenty-five additional species, of which no fewer than twenty are new to science, have come to light. Nine of the new species have been named, two are pseudomorphs, and nine, owing to paucity of material, have not yet been described. The minerals found this year include Trechmannite (fine crystals), Baumhauerite (curiously striated and distorted crystals), Seligmannite (a large crystal 20 mm. in length), Jordanite (a twin about 301), Dufrenoysite (a twin about 001), pseudomorphs of Dolomite and Baumhauerite after Scapolite (?).—Note on the Thirty-two Classes of Symmetry, by Mr. H. Hilton. — Specimens of Turnerite from Cornwall were exhibited by Mr. Russell, and crystals of Sartorite by Dr. Trechmann.

CORRESPONDENCE.

THE SOMABULA DIAMOND FIELD.

Sir,—I notice in your December issue[1] a comment by Dr. Flett on my paper on the Somabula Diamond Field, and I take this opportunity of expressing my regret that it was published just before a further visit to the field under the more favourable conditions now prevailing. It is unquestionable, as Dr. Flett implies, that most of the mineral locally regarded as enstatite is really staurolite. It did not occur to me to doubt the original determination of this mineral as a rhombic pyroxene, until I recently secured some fragments with faces showing the characteristic angles of staurolite. Andalusite may also be added to the list of what I have termed "unequivocal contact minerals." There can be no doubt, in fact, that the characteristic minerals of the alluvial deposit come chiefly from the margins of the granite mass which it overlies.

But this does not in the least alter the position as regards the original source of the diamonds. It is significant, for instance, that though diamond is almost exactly of the same specific gravity as chrysoberyl, topaz, and staurolite, the quantity of these latter has no relation whatever to the abundance or even to the presence of the diamond. The only mineral which shows indications of such a relationship is garnet, a possible 'pipe' mineral, by the way. The sapphires, rubies, and chrysoberyls are also exceedingly water-worn, while the diamonds are in many cases perfectly unabraded, though those found in the present-day stream which cuts into the old alluvial are usually considerably worn, showing they are susceptible to wearing action.

Perhaps a local experience of over five years and the fact of having made most careful field examinations of the vicinity may be permitted

[1] See Geol. Mag., December, 1906, pp. 569–570.